OPERATION & MAINTENANCE

HANDBOOK

MODEL 111
PULSE GENERATOR

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OPERATION & MAINTENANCE

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MODEL 111

PULSE GENERATOR

Part Number 37000-425

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DATAPULSE
DIVISION
SYSTRON DONNER
CORPORATION

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Model 111 Pulse Generator

The Model 111 is a high speed general purpose pulse generator for laboratory application. Controllable pulse parameters include pulse rate, delay, width, amplitude, baseline offset, and rise and fall time. Selectable modes of operation are positive or negative polarity, single or double pulse output, external triggering and gating, and manual single cycle operation.

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LIST OF SCHEMATICS

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41000-105	Block Diagram
40000-170	Schematic - Front End Model 110B/111
40000-171	Output Amplifier and Amplitude Control, Model 111
40000-172	Baseline dc Level Attenuator
40000-155	Grounded Power Supply
40000-156	Isolated Power Supply

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ADDENDA AND ERRATA

SECTION I

SPECIFICATIONS

1.1 Repetition Rate

Continuously variable from 4 hertz to 40 megahertz in seven decade ranges. Maximum rate of 25 megahertz in the double pulse mode and variable delay down to 20 nanoseconds allow the simulation of repetition rates up to 50 megahertz.

1.2 External Trigger

Operates at single cycle to 40 megahertz (25 megahertz maximum in the double pulse mode) from ±1.5 volt pulses with a rise time of less than 5 nanoseconds and a duration greater than 10 nanoseconds. A greater trigger duration is required for slower rise times or lower amplitudes. Sine wave triggering may be obtained from 10 hertz to 40 megahertz with an amplitude of 1 volt rms or more. A sensitivity control is provided to allow adjustment for noise rejection. Input impedance may be selected by a front panel switch as 50 or 500 ohms. The maximum input power that may be applied safely is 1 watt.

1.3 Single Cycle

Operation of a front panel pushbutton provides one cycle of output (single or double pulse, as selected by the PULSE MODE switch).

1.4 Gated Operation

Positive external gate signals greater than 3.5 volts interrupt the main output but do not block the sync output. Negative signals do not inhibit the outputs. The maximum level that may be applied safely is ±25 volts. Input resistance is approximately 1,000 ohms.

1.5 Sync Output

Negative 2 volts with approximately 20 nanoseconds duration and 5 nanoseconds rise and fall times into a 50 ohm load. In the single pulse mode, the sync output occurs approximately 95 nanoseconds after the external trigger is applied. In the double pulse mode, the sync output occurs approximately 25 nanoseconds after the external trigger is applied.

1.6 Pulse Mode

Single or double pulse operation is selected by the pulse mode switch.

1.6.1 Single Pulse Mode

A single pulse occurs approximately 15 nanoseconds prior to the sync output when the pulse delay controls are set to minimum. This permits the pulse output to be adjusted to coincide with the sync output.

1.6.2 Double (Twin) Pulse Mode

Two essentially identical pulses per cycle occur at the outputs. One pulse appears approximately 30 nanoseconds after the sync output trigger, and the second at a time determined by the pulse delay controls. Pulse width, amplitude, and transition times are controlled simultaneously for the pulse pair.

1.7 Pulse Delay

Single pulse delay is measured at the 50% amplitude point between the leading edges of the sync output trigger and the main output pulse set for minimum rise time. Double pulse delay is measured from the leading edge of the first main output pulse to the leading edge of the second pulse. Delay is variable over 75% of the pulse period up to 1 megahertz repetition rate, decreasing to 40% at 20 megahertz and 15% at 40 megahertz.

1.7.1 Single Pulse Delay

Pulse delay is continuously variable from approximately 15 nanoseconds advance to 50 milliseconds delay in six decade ranges plus one 50 nanosecond range.

1.7.2 Double Pulse Delay

Pulse delay is continuously variable from 20 nanoseconds to 50 milliseconds with the minimum delay increasing to approximately 40 nanoseconds at low repetition rates.

1.8 Pulse Duration

Continuously variable from typically 8 nanoseconds (10 maximum) to 500 microseconds covered in 5 ranges. Maximum duty cycle is typically 85%, decreasing to at least 50% at 40 megahertz.

1.9 Pulse Polarity

Positive or negative output is selected by a front panel switch.

1.10 Pulse Amplitude

Continuously variable from 150 millivolts to 5 volts into 50 ohms, covered in three ranges.

1.11 Rise and Fall Time

Measured from 10% point to 90% point with the output terminated in 50 ohms. Continuously variable control from less than 2 nanoseconds rise time and 3 nanoseconds fall time to at least 500 nanoseconds is provided in two ranges with a common range switch and separate vernier controls. Minimum rise time of 2 nanoseconds is realized at 5 volts amplitude, falling off to 2.4 nanoseconds at amplitudes below 500 millivolts. Minimum fall time of 3 nanoseconds is realized at 5 volts, increasing to 4 nanoseconds minimum at reduced amplitudes. Rise and fall times remain constant with amplitude range switch, while slope remains constant with changes in the amplitude vernier control. Transition times are linear within ±5% at rise times slower than 10 nanoseconds and fall times slower than 40 nanoseconds.

1.12 Baseline dc Level

Continuously variable to ±5 volts. Accuracy is ±50 millivolts for pulse output duty cycles of 50% or less. A front panel switch allows use either for pulse offset or as an auxiliary dc power supply. Symmetrical regulation characteristics permit the power supply to be used as a source, load, or precision shunt regulator. Maximum available current is 200 milliamperes.

1.13 Jitter

Repetition rate, delay, and width jitter are each less than 0.05% or 50 picoseconds, whichever is greater.

1.14 Waveform Aberration

Overshoot, undershoot, ringing, and top slope aberration are each less than 5% into 50 ohms.

1.15 Output Protection

Output stages will not be damaged by any combination of panel control settings, short circuits of any duration, or back voltages up to 5 volts.

1.16 Operating Temperatures

Rated for operation in ambient temperatures of 0° to 50° C.

1.17 Power Required

Approximately 100 watts at 50 to 400 hertz and 105 to 125 volts or 210 to 250 volts as selected by rear panel switch.

1.18 Physical Characteristics

Die cast front and back panels; face plate has brushed aluminum finish with etched and filled markings. Top and bottom covers are attached by four quick-release, quarter-turn nylon fasteners. Signal connectors are BNC type. Weight is approximately 27 pounds. Dimensions are: 16-3/4 inches wide by 5-1/4 inches high and 13-3/4 inches deep. The instrument may be rack mounted (5-1/4 inches high by 19 inches wide) by specifying Model 111R or by installing Type 1004 Rack Mounting Set.

1.19 Accessories Furnished

An eight-foot power cord with NEMA three-prong plug and one operation and maintenance handbook are supplied with the instrument.

1.20 Accessories Available

Type 2302 Pulse Mixer; Type 2003A Power Termination, 50 ohms, 25 watts; Type 1004 Rack Mounting Set; and extra operation and maintenance handbooks.

SECTION II

OPERATION

CAUTION

The outputs are designed for 50 ohm resistive loads. An inductive load or active circuit connected directly to an output may damage the instrument. Refer to paragraph 2.3 (Application Information) for non-standard load connection and output mixing instructions.

2.1 Controls and Connectors (See Figure 2-1)

2.1.1 Power Switch

The POWER switch connects ac power to the transformer primaries within the instrument and lights the pilot lamp when it is turned ON.

2.1.2 Repetition Rate

The REPETITION RATE rotary switch selects either the triggered mode or the repetition rate range for internally triggered operation. The smaller knob provides continuously variable control for all range settings except the 4-40 MHz range which has a separate vernier control knob. There are six decade ranges and the instrument is set to the rate indicated by the position of the rotary switch when the vernier knob is fully clockwise.

The SINGLE CYCLE position permits the unit to be triggered manually for one cycle of output by the SINGLE CYCLE pushbutton.

The EXT TRIG (+) and (-) positions provide instrument triggering from an external source by either a positive or negative going waveform.

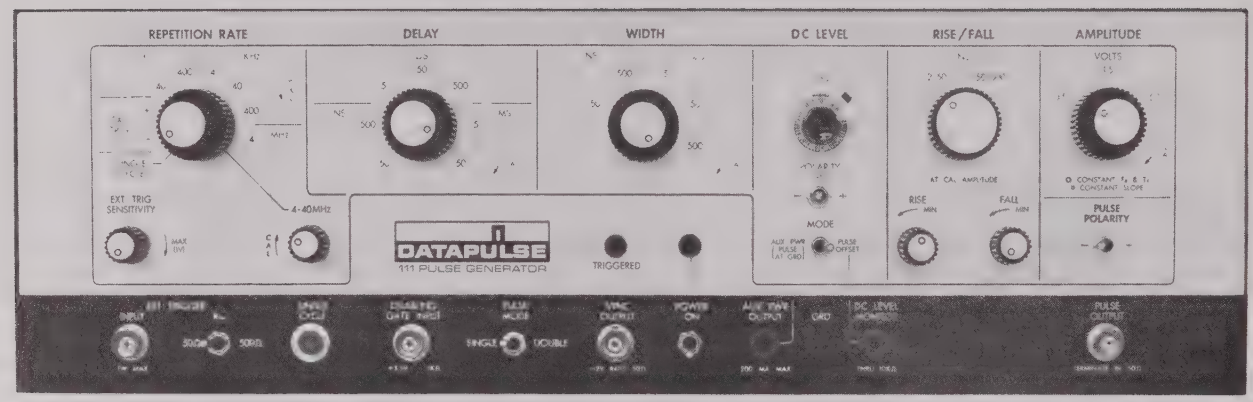
The EXT TRIG SENSITIVITY knob provides attenuation control of the input trigger signal. The TRIGGERED lamp lights when the sync output is present and provides a guide for EXT TRIG SENSITIVITY adjustments.

The EXT TRIGGER R_{IN} switch selects either 50Ω or 500Ω for the external trigger input impedance. The 50 ohm position is for fast rise time or high frequency input signals and the 500 ohm position is for slow signals to minimize loading of the source.

The EXT TRIGGER INPUT connector is provided for application of the external trigger signal.

2.1.3 Gate Input

The DISABLING GATE INPUT permits the normally continuous main pulse output to be disabled by an externally applied signal so that it can provide controlled bursts of pulses.



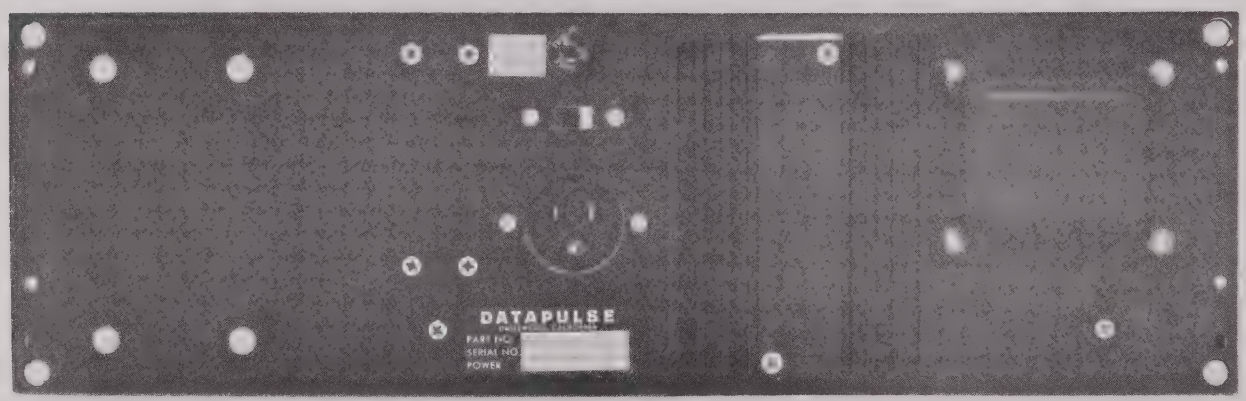


Figure 2-1. Model 111 Controls and Connectors.

2.1.4 Pulse Mode

SINGLE or DOUBLE pulse operation is selected by the PULSE MODE switch. Two identical pulses per cycle occur in the output in the double pulse mode; one approximately 30 nanoseconds after the sync output and the second at a time determined by the pulse delay controls. Only the second pulse occurs in the single pulse mode, and in this case the sync pulse is delayed 70 nanoseconds to allow the single pulse to be positioned in advance of the sync pulse.

2.1.5 Sync Output

The SYNC OUTPUT provides system clock trigger pulses on both internally and externally triggered operations. The TRIGGERED lamp lights when the sync output is present.

2.1.6 Pulse Delay

The DELAY rotary switch selects one of seven ranges and the smaller vernier knob provides continuously variable control for each range. The instrument is set to the delay indicated by the rotary switch when the vernier is fully clockwise.

2.1.7 Pulse Width

The WIDTH rotary switch selects one of five ranges and the smaller vernier knob provides continuously variable control for each range. The instrument is set to the width indicated by the rotary switch when the vernier is fully clockwise.

2.1.8 Rise and Fall Time

The RISE/FALL rotary switch selects one of two transition time ranges and the smaller, separate RISE and FALL verniers provide continuously variable control for each range. Transition time is affected by the AMPLITUDE vernier which reduces the transition time because it holds the slope constant when it is used for pulse output attenuation. Attenuation by the AMPLITUDE range selector changes the slope and not the transition time.

2.1.9 Pulse Amplitude

The AMPLITUDE rotary switch selects one of three ranges and the smaller vernier knob provides continuously variable control for each range. The instrument is set to the amplitude indicated by the rotary switch when the vernier is fully clockwise.

2.1.10 Pulse Polarity

The main pulse output is either positive or negative as selected by the PULSE POLARITY switch.

2.1.11 Pulse Output

The main pulse output of the instrument is taken from the PULSE OUTPUT signal connector.

2.1.12 Baseline dc Level

The dc level of the pulse baseline with respect to ground is determined by the settings of the DC LEVEL controls. Baseline dc level is continuously variable from 0 to 5 volts by the vernier control when the MODE switch is in the PULSE OFFSET position and the POLARITY switch is in either the (+) or (-) position. Offset may have the same polarity as the pulse. The DC LEVEL MONITOR jack is provided for monitoring the baseline offset.

The internal power supply for baseline dc level may be used as an auxiliary power supply when the MODE switch is in the AUX PWR position and the offset POLARITY switch is in the ZERO position. The AUX PWR OUTPUT and the GRD jacks provide outputs for the dc power supply. Symmetrical regulation characteristics permit the power supply to be used as a load or precision shunt regulator.

2.1.13 Fuse

A three ampere fast blow fuse on the back panel provides ac input overload protection.

2.1.14 Power Input

A three-prong recessed male connector on the back panel is provided for ac power connection to the unit by a NEMA three-wire line cord.

2.1.15 115/230 Line Voltage Switch

A slide switch on the back panel near the fuse connects the power transformer primaries either in parallel for operation from a 115 volt power source, or in series for a 230 volt input.

2.2 Functional Verification

2.2.1 Equipment (or equivalent) Required

a. A general purpose oscilloscope of at least 15 megahertz bandpass with triggered sweep.

NOTE: A full range operation test in addition to the basic functional checks outlined here will require a sampling oscilloscope with a coaxial attenuator for the fast transition times and high repetition rates.

b. A 50 ohm coaxial termination capable of at least 2 watts dissipation such as a Datapulse 2003 Power Termination.

NOTE: A one watt termination is adequate for most combinations of control settings but output power approaches 2 watts for high duty cycle waveforms when the dc level and pulse amplitude are maximum and the same polarity.

c. A 50 ohm coaxial termination capable of at least 1/2 watt dissipation.

d. Three 50 ohm coaxial cables with BNC connectors.

e. A general purpose signal generator capable of delivering 2 volts into 500 ohms to check the external trigger and disabling gate functions (the square-wave amplitude calibrator of many oscilloscopes is adequate).

2.2.2 Initial Instrument Settings

Control	Setting
POWER switch	off
REPETITION RATE selector	40 KHz
REPETITION RATE vernier	fully clockwise
DELAY selector	5 µs
DELAY vernier	fully clockwise
WIDTH selector	5 µs
WIDTH vernier	fully clockwise
DC LEVEL control	0 V
DC LEVEL POLARITY switch	ZERO
DC LEVEL MODE switch	PULSE OFFSET
RISE/FALL selector	50-500 NS
RISE vernier	fully counterclockwise
FALL vernier	fully counterclockwise

Control	Setting
AMPLITUDE selector	0.5 VOLTS
AMPLITUDE vernier	fully clockwise
PULSE POLARITY switch	(+)
PULSE MODE switch	SINGLE

Set the oscilloscope sweep speed to 2 microseconds/cm, the vertical sensitivity to 0.2 volts/cm and the trigger slope switch to negative.

2.2.3 Test Connections

CAUTION

Check the position of the 115/230 volt slide switch on the back panel for agreement with the line voltage before connecting the power cord.

a. Connect the instrument to a suitable power source.

b. Connect a 50 ohm cable from the SYNC OUTPUT to the oscilloscope trigger input with the cable terminated in 50 ohms (1/2 watt) at the oscilloscope.

c. Connect a 50 ohm cable between the PULSE OUTPUT and the oscilloscope vertical input with the cable terminated in 50 ohms (2 watts) at the oscilloscope.

2.2.4 Functional Test

a. Turn the POWER switch ON and note that both the POWER and TRIGGERED indicator lamps light.

b. Turn the oscilloscope on, adjust the trigger level control for a stable display, and note that a single positive pulse appears on the oscilloscope (5 microseconds wide and 0.5 volts high with 50 nanoseconds rise and fall times).

c. Turn the PULSE POLARITY switch to (-) and note that the pulse on the oscilloscope is negative. Return the PULSE POLARITY switch to (+).

d. Turn the AMPLITUDE vernier counterclockwise and note that the pulse amplitude decreases as the knob is turned. Turn the vernier fully clockwise.

e. Set the oscilloscope vertical sensitivity to 1.0 volt/cm (be sure a coaxial attenuator is connected to the PULSE OUTPUT if a sampling oscilloscope is used) and check the pulse amplitude for both the 1.5 VOLT and the 5.0 VOLT positions of the rotary switch. Return the AMPLITUDE switch to the 0.5 VOLT position and the oscilloscope vertical sensitivity to 0.2 volt/cm.

f. Turn the RISE vernier clockwise and note that the pulse leading edge slope increases to approximately 500 nanoseconds when the knob is fully clockwise.

g. Repeat step (f) for the FALL vernier.

h. Turn the RISE/FALL rotary switch to the 2-50 NS position and verify that the slope of both the leading and trailing edges decrease from 500 nanoseconds to 50 nanoseconds.

i. Turn both the RISE and FALL verniers fully counterclockwise and verify that their slopes decrease as the knobs are turned. Return the RISE/FALL rotary switch to the 50-500 NS position.

j. Set the oscilloscope vertical sensitivity to 2 volts/cm and turn the DC LEVEL POLARITY switch to (+). Verify that the baseline is offset in the positive direction (up to 5 volts) as the DC LEVEL knob is turned clockwise.

k. Repeat step (j) for the (-) position of the POLARITY switch. Return the DC LEVEL knob to 0 V, the POLARITY switch to ZERO, and the oscilloscope vertical sensitivity to 0.2 volts/cm.

l. Turn the WIDTH vernier counterclockwise and verify that the pulse width decreases to less than 500 nanoseconds as the knob is turned fully counterclockwise. Leave the vernier in the fully counterclockwise position.

m. Switch the PULSE MODE switch to the DOUBLE position and verify that two identical pulses appear on the oscilloscope approximately 5 microseconds apart. Turn the DELAY vernier counterclockwise and note that the second pulse moves to the left as the knob is turned. Return the PULSE MODE switch to the SINGLE position and both the DELAY and WIDTH verniers to their fully clockwise positions.

n. Set the oscilloscope sweep speed to 20 microseconds/cm and note that several pulses appear on the oscilloscope. Turn the REPETITION RATE vernier counterclockwise and verify that the number of pulses decreases and the space between pulses increases as the knob is turned. Return the REPETITION RATE vernier to its fully clockwise position.

o. Connect either the signal generator (or the square-wave amplitude calibrator of the oscilloscope) with its amplitude at minimum to the EXT TRIGGER INPUT by means of a coaxial cable. Turn the REPETITION RATE switch to (+) EXT TRIG and the R_{IN} switch to 50Ω (or 500Ω if required); note that the TRIGGERED lamp goes out and the pulses disappear from the oscilloscope. Set the signal generator frequency to 40 kilohertz and increase its amplitude until the TRIGGERED lamp lights and several pulses appear on the oscilloscope. Return the REPETITION RATE switch to 40 KHz and disconnect the signal generator from the EXT TRIGGER INPUT (the pulses should appear again on the oscilloscope and the TRIGGERED lamp should light).

p. Connect the AUX PWR OUTPUT to the DISABLING GATE INPUT by means of a coaxial cable and set the DC LEVEL knob to 0 V, its POLARITY switch to (+), and the MODE switch to AUX PWR. Turn the DC LEVEL knob clockwise until the pulses disappear from the oscilloscope (the TRIGGERED lamp should remain on).

2.3 Application Information

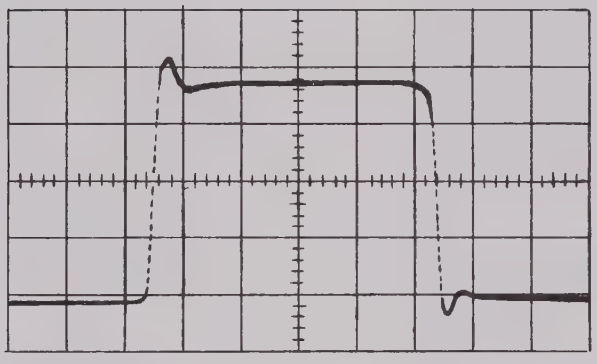
2.3.1 Output Termination

The Model 111 is designed for a 50 ohm load. It is necessary to use 50 ohm coaxial cables and 50 ohm load terminations to get clean waveshapes, fast transition times, and a minimum of pulse aberration. The terminating impedance must not vary more than ±5% if instrument specifications are to be met. Impedances greater than 50 ohms cause saturation of the output amplifiers and introduce storage time effects; load terminations less than 50 ohms increase the collector voltage in the output amplifiers and cause overshoot and ringing. Figure 2-2 illustrates the effect of incorrect termination on pulse waveform.

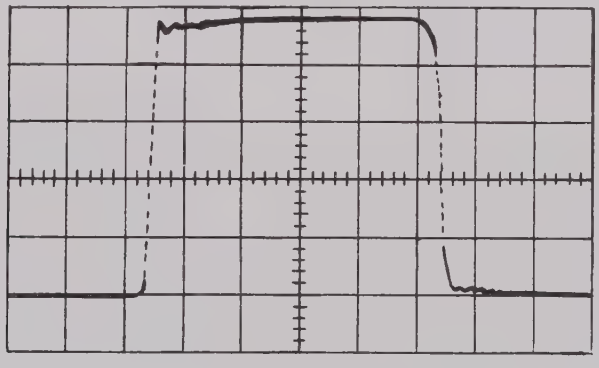
> NOTE: Load terminations (and attenuators) used with the Model 111 should be rated for 2 watts dissipation because pulse output power approaches 2 watts for high duty cycle waveforms when the dc level and the pulse amplitude are maximum and the same polarity.

2.3.2 Output Cabling

In many cases the pulse generator will be connected to a load that is several feet away. Clean waveforms with low distortion are maintained by using a 50 ohm coaxial cable and terminating it in 50 ohms at the load rather than at the pulse generator. Pulse distortion caused by terminating at the instrument, using clip leads, or using coaxial cable with the wrong characteristic impedance is illustrated in Figures 2-3a through e. Distortion is not apparent in slow rise and fall time pulses as shown in Figure 2-3f.



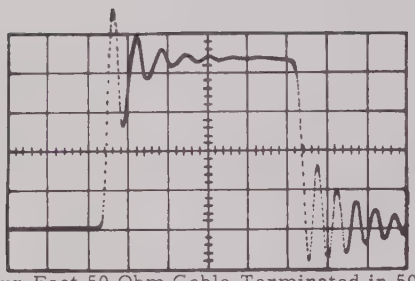
a. Full Amplitude Positive Pulse Terminated in 40 Ohms.



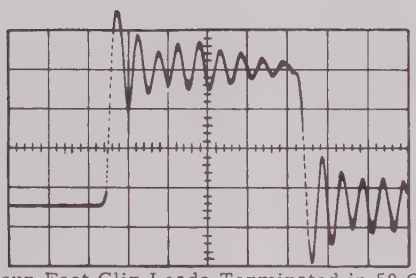
b. Full Amplitude Positive Pulse Terminated in 60 Ohms.

Oscilloscope Setting: 50 ns/cm and 1 V/cm.

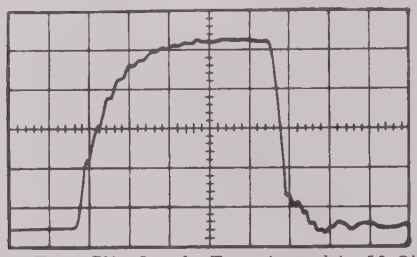
Figure 2-2. Effect of Incorrect Termination on Pulse Waveform.



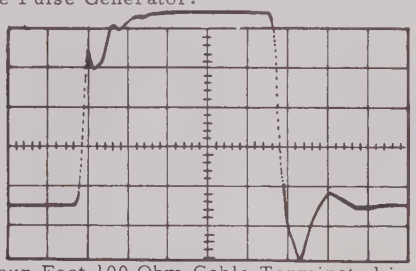
a. Four Foot 50 Ohm Cable Terminated in 50 Ohms at the Pulse Generator.



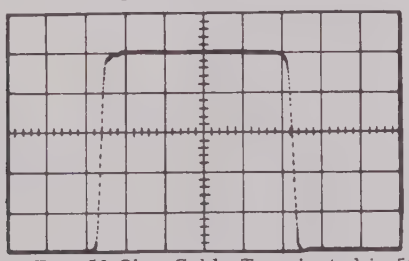
b. Four Foot Clip Leads Terminated in 50 Ohms at the Pulse Generator.



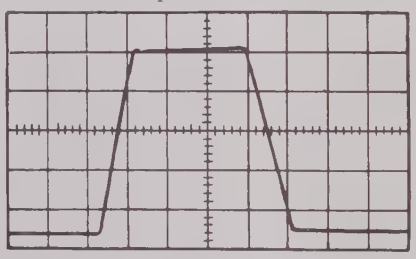
c. Four Foot Clip Leads Terminated in 50 Ohms at the Oscilloscope.



d. Four Foot 100 Ohm Cable Terminated in 50 Ohms at the Oscilloscope.



e. Four Foot 50 Ohm Cable Terminated in 50 Ohms at the Oscilloscope.



f. Four Foot Clip Leads Terminated in 50 Ohms at the Oscilloscope with 0.5µs Rise and Fall Times.

Oscilloscope Setting: 50 ns/cm and 1 V/cm for a. through e.;
0.5µs/cm and 1 V/cm for f.

Figure 2-3. Pulse Distortion Caused by Incorrect Cabling and Load Termination.

2.3.3 Nonlinear Loads

Operating directly into nonlinear devices, such as transistors and diodes that exhibit high impedance in one direction and low impedance in the other, causes waveform distortion. This can be prevented by terminating the pulse generator in a network that provides uniform loading in both directions. Two methods for driving the base of a transistor, or operating into a diode (the base-emitter junction of a transistor resembles a diode), are illustrated in Figure 2-4. In the resistor coupled network, transistor Q_L is biased off between pulses and is turned on during the pulse interval, while in the capacitor coupled circuit, Q_L is quiescently on and is turned off by the applied pulse.

Values for resistors R_C, R_2, R_3 and capacitor C_1 depend primarily on the transistor characteristics in both circuits. Resistor R_1 is calculated from the equations given in the figure to provide proper termination for the pulse generator (50 ohms) and prevent ringing. Capacitor C_2 in the capacitor coupled network, depends on pulse width and repetition rate, and is determined by the given equations. For a PNP transistor, the polarity of the input pulse, the applied voltage, and the diode are reversed. In both networks, load mismatch and waveform distortion are more pronounced at fast rise and fall times.

2.3.4 Output Decoupling

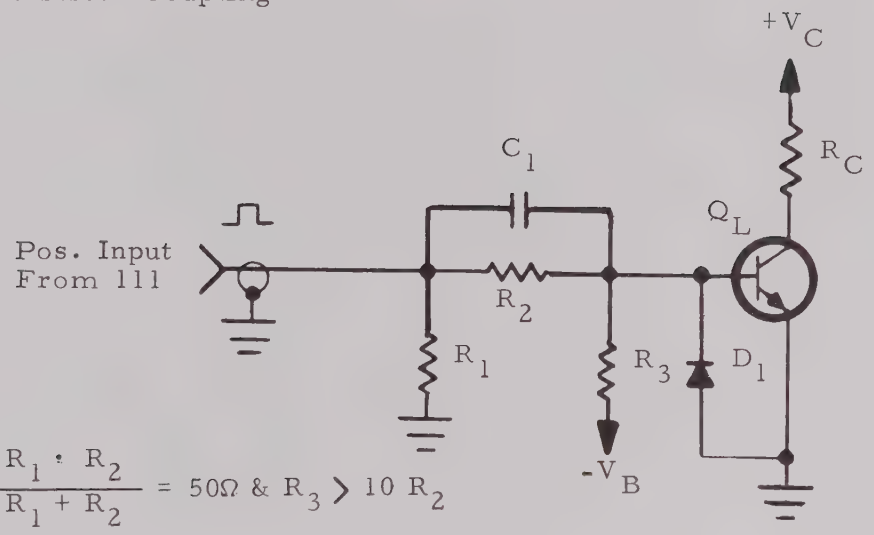
An emitter follower may be used to decouple the output from a nonlinear load when the passive networks of Figure 2-4 are unsuitable. The circuits of Figure 2-5 are useful, for example, when more power is required than can be obtained from either the resistor or the capacitor coupled circuit. The transistor selected must have enough power and gain to meet load requirements and should have high frequency response characteristics with low capacity input for fast transition times and minimum pulse distortion. The 22 ohm resistor in the output is a parasitic suppressor that reduces pulse aberrations. The value of emitter resistor R_E and the operating voltage V_C depends on the load current and voltage requirements.

2.3.5 Reactive Loads

Reactive loads connected directly to the output will produce pulse distortion; inductive loads may damage the instrument. When it is necessary to drive an inductive load such as a pulse transformer, the instrument should be protected against the inverse voltages generated by energy stored in the transformer. Figure 2-6 shows how diodes may be used to dampen the reverse voltage swings and prevent the output transistors from being exposed to voltages above their inverse ratings.

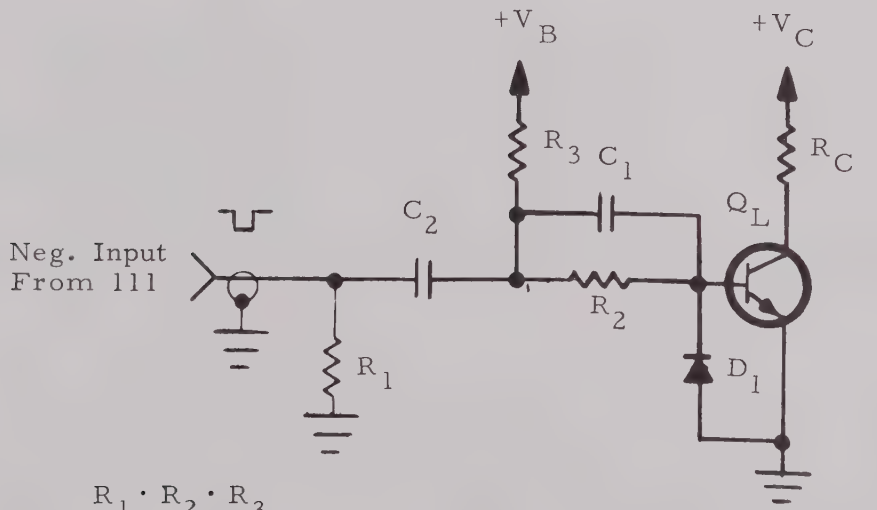
> NOTE: When an output is operated into an inductive load, its baseline switch should be in the ground position to avoid unnecessary loading of the baseline offset circuit.

a.- Resistor Coupling



$$\frac{R_1 \cdot R_2}{R_1 + R_2} = 50\Omega \;\&\; R_3 > 10\,R_2$$

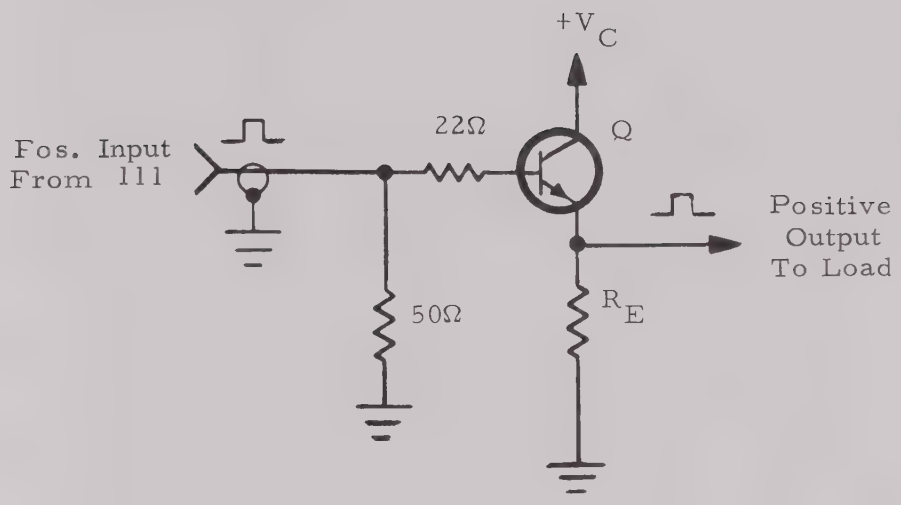
b. Capacitor Coupling



$$\frac{R_1 \cdot R_2 \cdot R_3}{R_1 \cdot R_2 + R_2 \cdot R_3 + R_1 \cdot R_3} = 500\,\Omega,\ 50\,C_2 > \text{Pulse Width} \;\&\; \frac{3}{50\,C_2} > \text{Rep Rate}$$

Figure 2-4. Networks for Transistor Loads.

a. Positive Output



b. Negative Output.

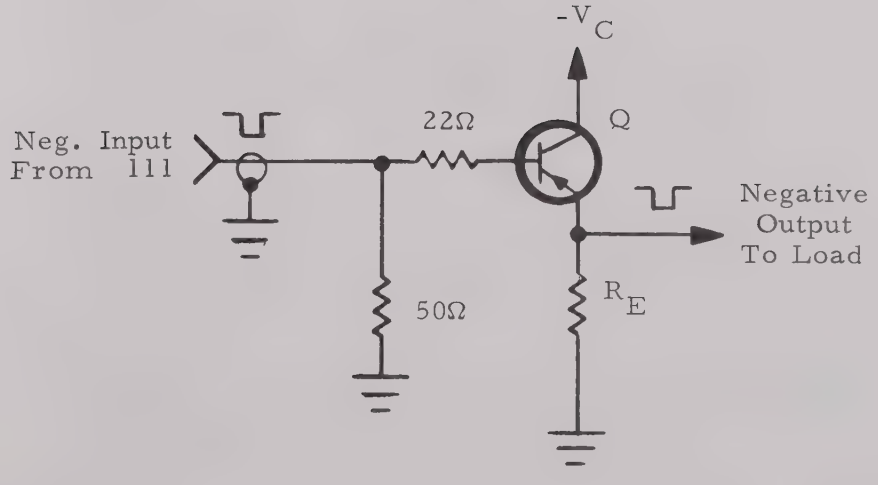
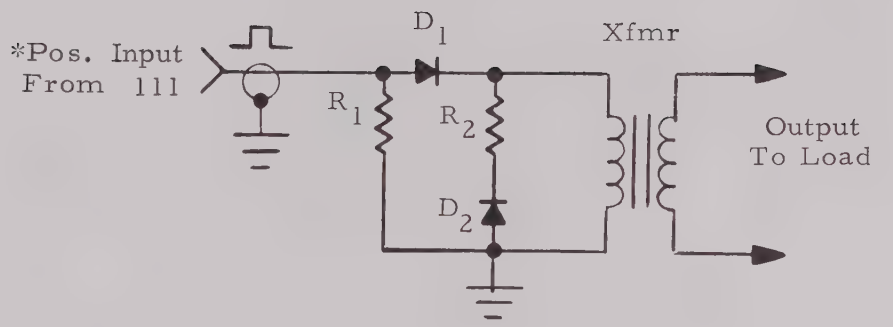


Figure 2-5. Output Decoupling Circuits.



R_1 = 75 - 150 Ω R_2 = 200 - 500 Ω, Diodes may be IN995s.

*Reverse Diode Polarity for Negative Pulse Input.

Figure 2-6. Reverse Voltage Protection.

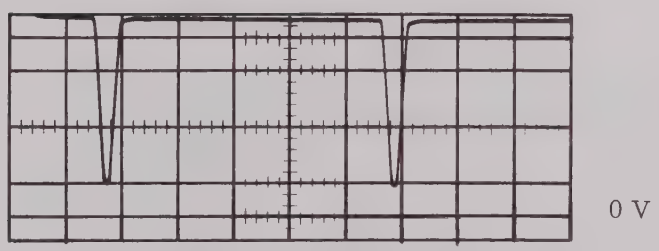


Figure 2-7. Negative Output With Positive Baseline Offset to Simulate 95% Duty Cycle Positive Output.

2.3.6 High Duty Cycle Operation

At duty cycles greater than 85% the delay and width circuits may fail, causing instability and amplitude reduction when the instrument is operated in the conventional manner. This limitation can be overcome, and duty cycles approaching 100% may be obtained, by using the opposite polarity output with same polarity baseline offset. Figure 2-7 illustrates a positive pulse with a duty cycle of 95% obtained from the negative output with positive dc offset; the offset control is set for a positive dc level equal to the amplitude of the narrow (5% duty cycle) negative pulse. Waveforms obtained in this manner are indistinguishable from waveforms generated in the conventional manner.

To avoid inaccurate data when operating in the conventional manner at duty cycles above 85%, always adjust the repetition rate first with the width and delay controls at minimum. If instability or amplitude reduction occurs when the width or delay controls are being set, use the technique described in the previous paragraph.

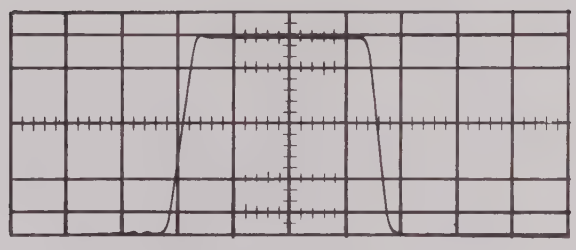
2.3.7 Baseline Offset

Simulation of almost all logic levels in use today is made possible by the instrument's variable baseline offset capabilities. Signals with built-in bias for driving transistors and vacuum tubes are obtained directly from its outputs. Figure 2-8 shows how the instrument may be used to simultaneously simulate both outputs at a multivibrator. Low level pulses may be used with substantial offset voltages as illustrated by the waveform of Figure 2-9 which simulates a regulated dc output. Voltage sensitive circuits can be tested by setting the baseline level near the operating threshold with the amplitude at minimum and then advancing the amplitude vernier until the circuit operates.

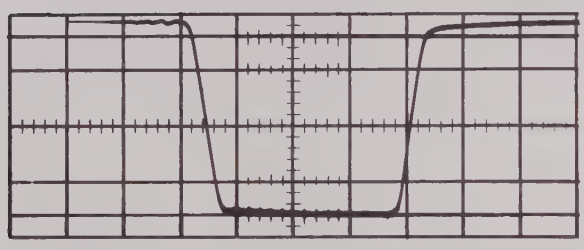
2.3.8 Output Mixing

The Model 111 output may be combined with other outputs (either same or opposite polarity) and applied to a common load if none of the amplitudes exceed 10 volts. The voltage limitation is imposed by the collector-to-emitter breakdown voltage of the output transistors. Mixing will in general degrade the transition times and cause pulse distortion due to unavoidable reactive components in the loading circuits. Best results for combining two same polarity outputs are obtained by using a Datapulse 2303 Pulse Mixer.

If the outputs (same or opposite polarity) of two 111's are directly mixed, the resulting amplitude will be much lower than their unmixed amplitudes (normally half) unless the attenuators are set for maximum output. The attenuators shunt the common load. The output impedance of the instrument is 50 ohms except when the amplitude range switch is in the 5 volt position (it is much higher for this setting). Thus, when mixed outputs are attenuated, the load on each instrument is substantially increased.



a. Positive Output.



b. Negative Output.

Figure 2-8. Simulation of Both Outputs of a Flip-Flop.

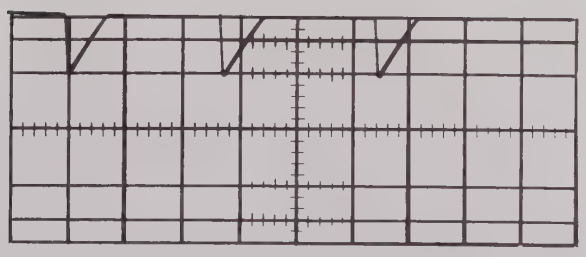


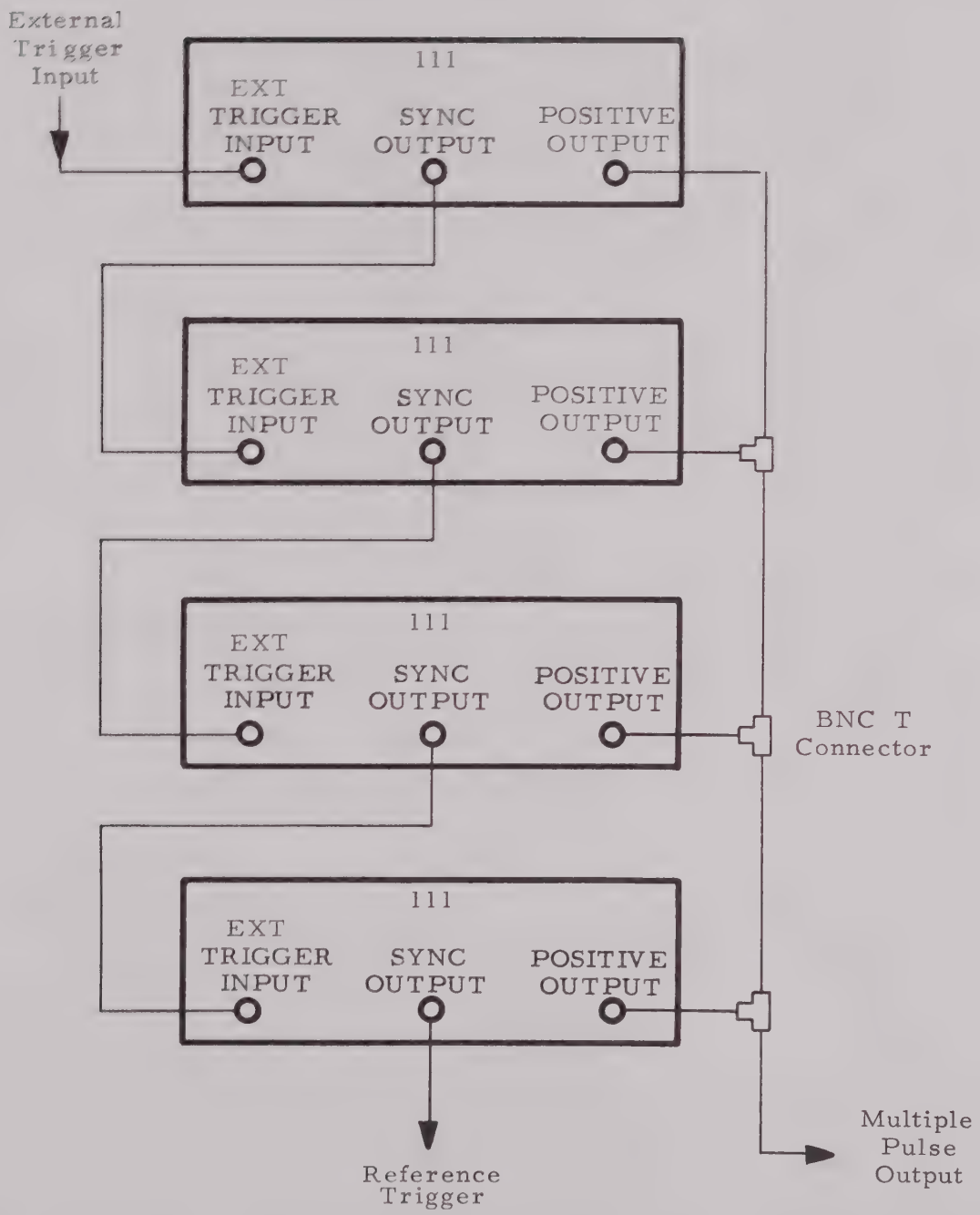
Figure 2-9. Regulated dc Output Simulated by 100 mV Negative Output With +5V Baseline Offset.

Several 111's may be connected together to simulate a multiple-pulse generator with all pulses selectable in polarity and pulse parameters controlled individually. The group may be driven in parallel (from an external source if desired) or in tandem as shown in Figure 2-10(using the sync output of one generator to externally drive the next). Pulse repetition rates well above 50 megahertz can be synthesized by this method. Good waveform fidelity is obtained by attenuating each pulse by its amplitude controls so that the instrument attenuators terminate the interconnecting cables in the characteristic impedance (50 ohms) and reduce pulse distorting reflections.

Baseline offset may be used when same polarity outputs are directly mixed. Only one baseline circuit can be used and the baseline switches of all the other units must be in the ground position. The instrument attenuators shunt the common output impedance and load the baseline circuit so that the offset range is reduced in proportion to the number of instruments. Offset control is unsuitable for opposite polarity mixing because the offset voltage reduces the amplitude of the same polarity output.

2.3.9 Positive Reference Trigger

The negative sync output may be adapted to applications requiring positive reference triggers by a Datapulse Type 2101 Inverting Transformer, available as an accessory.



NOTE:
1 - All cables are 50 ohm coaxial cables with BNC connectors.
2 - Connect BNC T connectors directly to output jacks and make interconnecting cables as short as possible.

Figure 2-10. Connections for Multiple-Pulse Output.

SECTION III

THEORY OF OPERATION

3.1 General Description

Refer to the Block Diagram (Schematic 41000-105) and the Waveform Diagrams (Figure 3-1) for the following discussions.

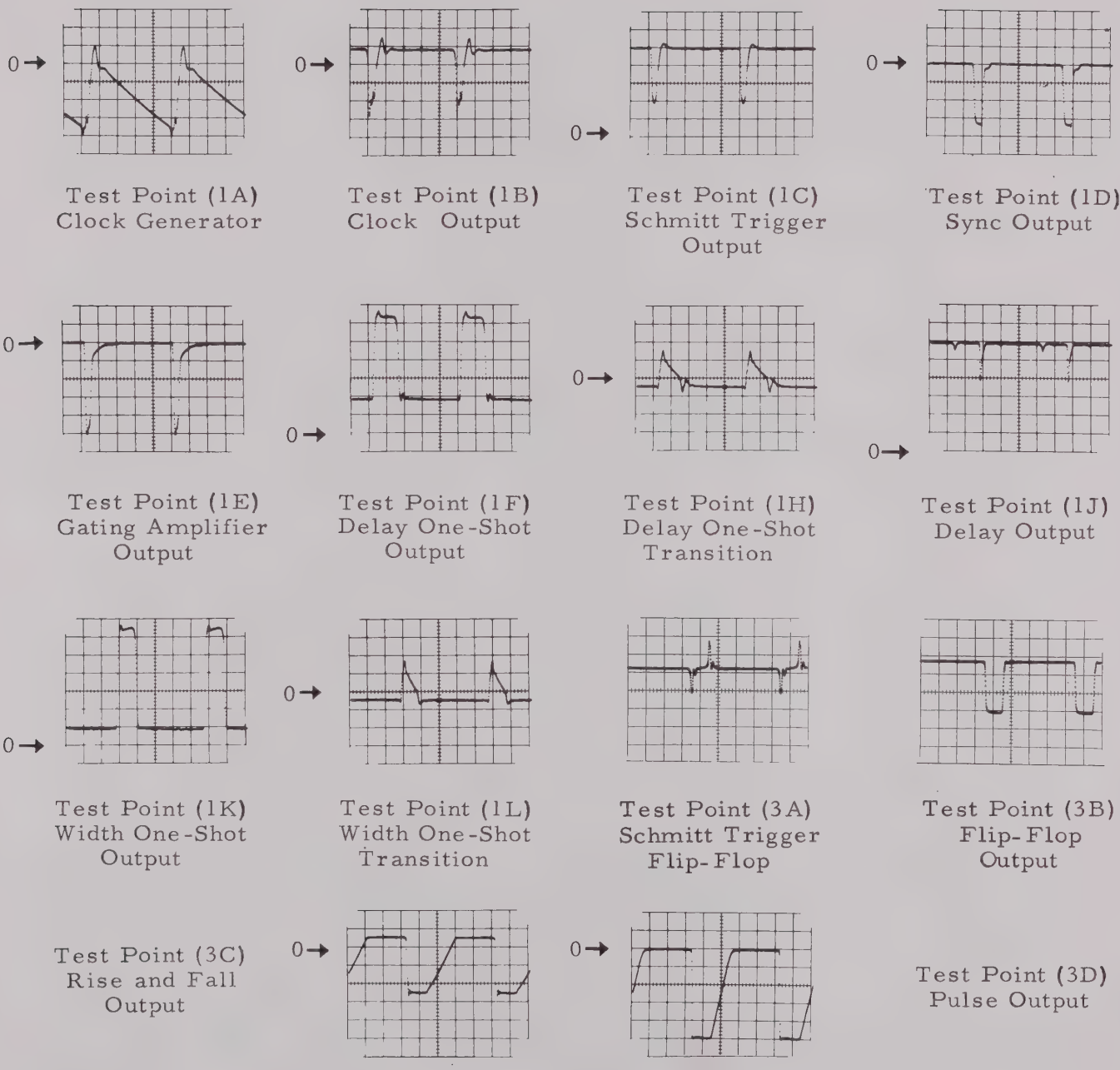
A synchronizing waveform with a variable repetition rate (waveform 1B) is produced by the clock generator. The repetition rate switch selects either this signal or an external trigger applied through the input amplifier, to drive the Schmitt trigger circuit. The output of the Schmitt trigger (1C) governs the operation of the remaining circuits and is applied to the sync driver and the gating amplifier circuits. The clock generator is disabled for both external trigger operation and for single cycle operation, when a pushbutton is used to trip the Schmitt trigger for one cycle of output.

The reference trigger (1C) is amplified by the sync driver and applied to the sync output amplifier through a delay line in the single pulse mode of operation. This delay compensates for the fixed delay in the main pulse circuits and permits the main pulse to be adjusted to coincide with the sync output (1D) by the delay controls. In the double pulse mode, the sync output is not delayed and occurs before the first pulse of the main output pair.

The gating amplifier is driven by the reference trigger, and when a disabling gate signal is not applied, its output (1E) triggers the delay one-shot circuit. Tunnel diodes shape the delay output (1J) to provide two identical triggering spikes, one at the beginning and one at the end of the delay interval. In the single pulse mode, the first triggering spike is inhibited and the width one-shot circuit is triggered only by the second spike. Both triggers are present in the double pulse mode, and the width one-shot circuit operates at the beginning as well as the end of the delay interval to provide two pulses per cycle of operation.

The output of the width one-shot circuit (1K) is shaped by the tunnel diode edge shaper to produce fast narrow spikes which are coupled to the isolated circuits by a pulse transformer. The output amplifier and pulse forming circuits are isolated from chassis ground because pulse polarity is switched by inverting the isolated circuits with respect to ground. Power is provided by a separate floating power supply. The toroidal balun compensates for the capacitance between the isolated circuits and chassis ground.

Leading and trailing edge pulses from the width one-shot circuit are coupled to the rise and fall circuits through the Schmitt trigger flip-flop which duplicates the output of the width one-shot circuit (3B). The rise and fall


0
Test Point (1A) Clock Generator
Test Point (1B) Clock Output
Test Point (1C) Schmitt Trigger Output
Test Point (1D) Sync Output
Test Point (1E) Gating Amplifier Output
Test Point (1F) Delay One-Shot Output
Test Point (1H) Delay One-Shot Transition
Test Point (1J) Delay Output
Test Point (1K) Width One-Shot Output
Test Point (1L) Width One-Shot Transition
Test Point (3A) Schmitt Trigger Flip-Flop
Test Point (3B) Flip-Flop Output
Test Point (3C) Rise and Fall Output
Test Point (3D) Pulse Output

REPETITION RATE: 4 MHz; WIDTH: 50 NS; DELAY: 50 NS; DC LEVEL: 0 V; RISE: 2 NS; FALL; 50 NS; AMPLITUDE: 5 VOLTS; PULSE POLARITY: (-); and PULSE MODE: SINGLE. The vertical scale is 1 V/cm; the horizontal scale is 50 ns/cm, with zero time at the same point on all diagrams.

Figure 3-1. Waveform Diagrams.

circuits establish leading and trailing edge transition times (3C). The output amplifier raises the current level to provide the required output amplitude (3D).

The amplitude control circuit maintains proper operating voltages at the final stages of the output amplifier, independent of baseline dc level. It also provides continuously variable vernier control of pulse amplitude for each range setting of the T-pad attenuator. The dc level circuit for baseline offset is a voltage regulator that monitors the baseline voltage and maintains it at the level set by the dc level potentiometer. A selector switch permits it to be used as an auxiliary power supply when it is not needed for baseline offset.

3.2 Circuit Description

3.2.1 Clock Generator

The clock generator illustrated in the simplified schematic of Figure 3-2 is a high frequency astable multivibrator. Transistors Q2 and Q5 comprise the basic oscillator with the waveform of test point 1A in Figure 3-1 at the emitter of Q2. Q2 switches on and off during each cycle, and Q5 is an emitter follower that drives timing capacitor C_T. Emitter follower Q1 provides a fixed voltage for the base of Q2, and Baker clamp diodes CR1 and CR2 prevent Q2 from saturating. The output is decoupled from the load by emitter follower Q6. Q3 and Q4 are local switches for the front panel range selector and are left out of the simplified circuit.

To visualize the operation of the circuit, assume that Q2 has just turned off. No current flows in R11 and the collector of Q2 and base of Q5 are at ground with the emitter of the conducting Q5 slightly above ground. C_T charges through R_T with the emitter of Q2 going negative towards -25 volts. When the emitter of Q2 becomes negative with respect to the fixed voltage at its base, Q2 conducts.

Both the collector of Q2 and the base of Q5 are driven sharply negative by the current in R11 when Q2 conducts. The emitter of Q5 follows its negative going base during this short interval and C_T quickly discharges through the low impedance path provided by Q2 and Q5. When C_T is discharged, the current in Q2 subsides and its collector voltage rises abruptly towards ground. The base and emitter voltages of Q5 also rise and the positive transition is coupled through C_T to the already positive going emitter of Q2. This regeneration quickly cuts off Q2 and the cycle repeats itself.

Values of C_T selected by the repetition rate range switch and the vernier settings of R_T determine the time constant, and hence the frequency of oscillation of the circuit.

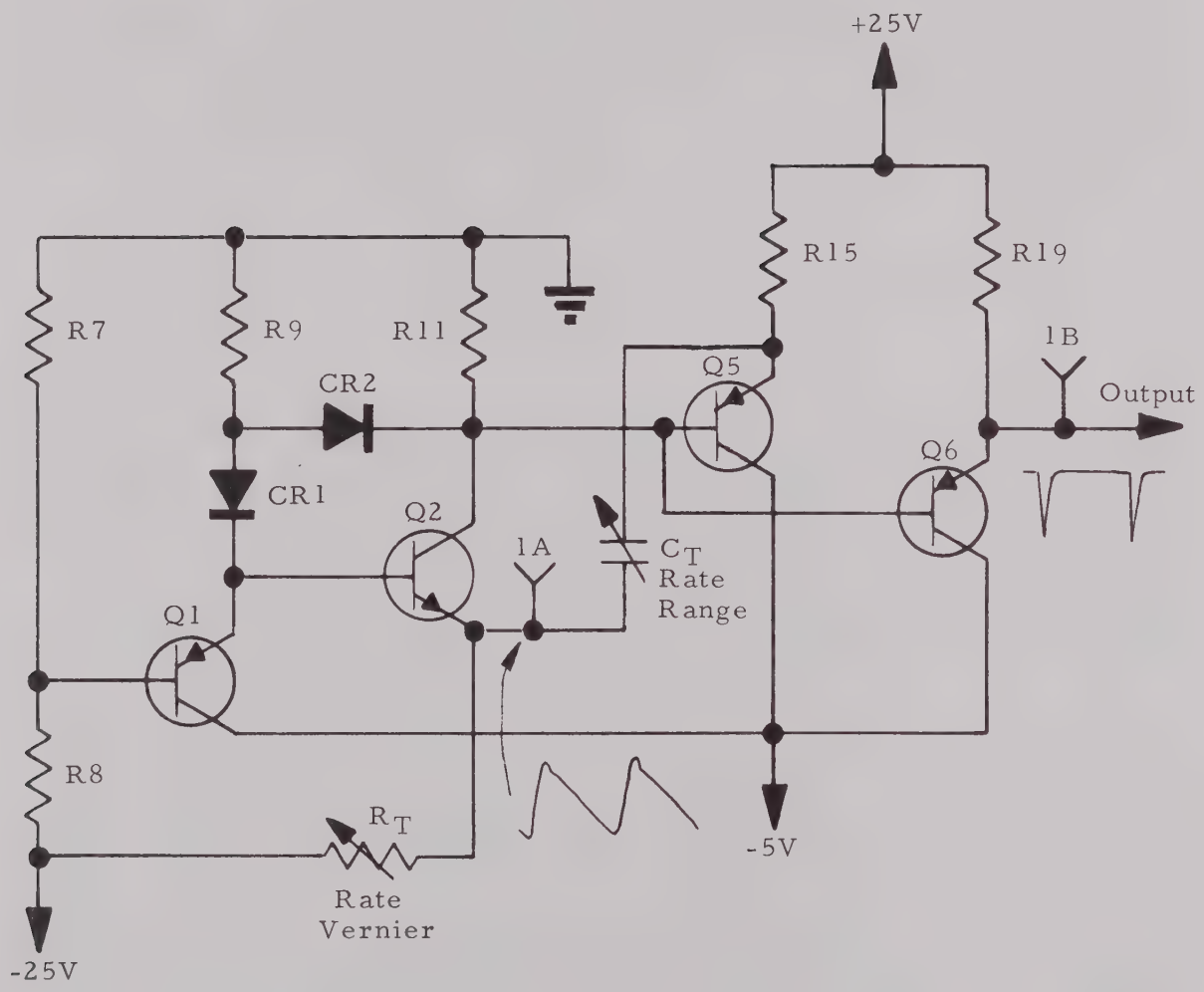


Figure 3-2. Clock Generator.

3.2.2 Schmitt Trigger

Figure 3-3 is a simplified schematic of the Schmitt trigger that generates the instrument's standard reference trigger (1C). It is driven by either the clock generator or a triggering signal from an external source. Its output has fast rise and fall times that are effectively independent of input waveform.

Transistor Q7 is on and Q8 is off in the quiescent state. A negative input signal causes Q7 to cut off and produces a positive voltage swing at its collector as the current in resistor R24 is cut off. The positive signal, coupled to its base by resistor R26 and capacitor C14, turns Q8 on. The emitter of Q8 follows its base and the positive transient is applied to the emitter of Q7. This regenerative feedback produces a fast negative pulse at the collector of Q8. The remaining circuits in the instrument are synchronized by this standard reference trigger.

3.2.3 Input Amplifier

The input amplifier generates the driving signal for the Schmitt trigger when the instrument is triggered from an external source. The circuit is composed of transistors Q9, Q10, and Q11 in schematic diagram 40000-170. Potentiometer R42 is an input attenuator for control of trigger sensitivity. The 50 ohm position of input impedance switch S41 is for proper termination of a 50 ohm source, and the 500 ohm position is for high impedance sources to reduce loading. Diode CR41 protects Q9 from excessive negative signals by clamping its base to the -5 volt supply.

The trigger input signal is applied to the base of emitter follower Q9, and the output of Q9 is ac coupled to the differential amplifier comprised of Q10 and Q11. In the absence of a signal, Q10 is on and Q11 is off because CR43 applies a positive bias to the base of Q10 and CR47 applies a negative bias to the base of Q11. When repetition rate switch S1 is in the (+) EXT position, CR45 clamps negative signals to ground and positive signals are applied to the base of Q11 through CR46. Positive signals turn Q11 on and its collector current produces a voltage drop in resistor R49. The resulting negative transient at the collector of Q11 is coupled to the Schmitt trigger through CR7.

In the (-) EXT position, CR44 clamps positive excursions to ground and negative signals are applied to the base of Q10 through CR42. These negative signals turn Q10 off and Q11 on by driving the base of Q10 negative with respect to the base of Q11. Again the negative pulses at the collector of Q11 are applied to the Schmitt trigger through CR7. The baseline of the triggering pulses is shifted from +5 volts to ground by CR48 for compatibility with the Schmitt trigger circuit.

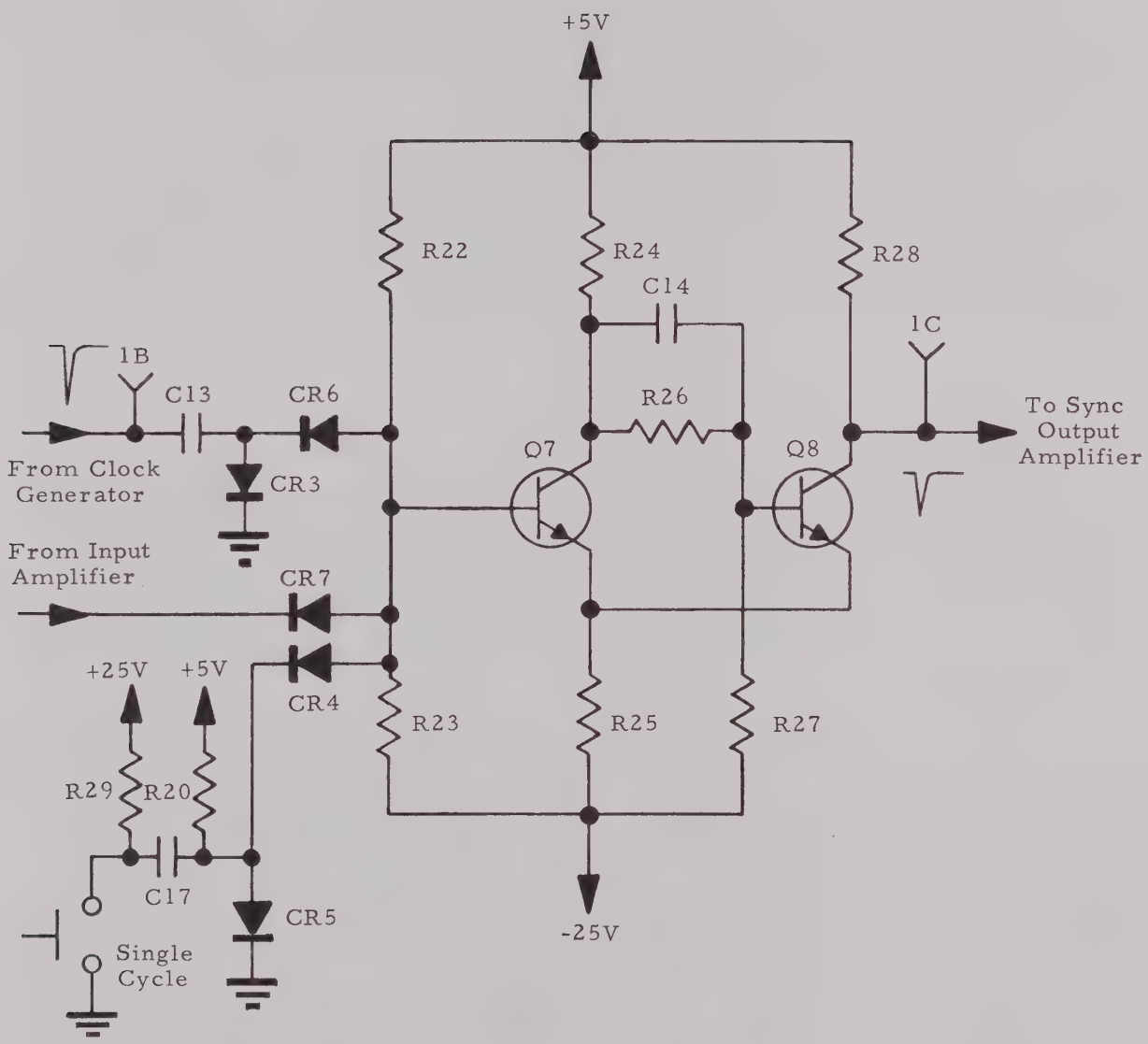


Figure 3-3. Schmitt Trigger.

3.2.4 Sync Output Amplifier

The sync amplifier consists of transistors Q12, Q13, and Q14 in schematic diagram 40000-170. Sync driver Q12 is an emitter follower that drives the 50 ohm delay line. Two stages of amplification are provided by Q13 and Q14.

The sync output is delayed 70 nanoseconds in the single pulse mode to compensate for the fixed delay in the pulse forming circuits. This makes it possible to adjust the main pulse to coincide with the sync output by means of the delay controls. In the double pulse mode, the sync output is not delayed and occurs approximately 35 nanoseconds before the first pulse of the output pair.

3.2.5 Triggered Lamp Driver

Transistors Q15 and Q16 in schematic diagram 40000-170 comprise a monostable multivibrator that drives the triggered lamp to indicate the presence of the sync output. Negative sync pulses turn Q15 on and result in the saturation of both Q15 and Q16 by means of positive feedback resistors R72 and R75 and capacitor C64. The lamp remains on until the charging current through C64 decays and Q15 and Q16 return to their nonconducting state between sync pulses.

3.2.6 Gating Amplifier

The gating amplifier interrupts the main pulse output in response to an external gate signal by blocking the output of the Schmitt trigger. The amplifier is composed of transistors Q17, Q18, and Q19 as shown in Figure 3-4. Q17 and Q18 form an OR gate which is followed by inverting amplifier Q19.

In the quiescent state, Q17 is on and Q18 is off because diode CR81 applies a positive bias to the base of Q17, and CR83 and CR84 bias the base of Q18 negative. Q17 is turned off by the negative signal applied to its base from the Schmitt trigger and a positive swing occurs at its collector. This transition is differentiated by C83 and coupled to the base of inverter Q19. The resulting negative trigger pulse at the collector of Q19 is used to drive the delay one-shot multivibrator.

A positive voltage applied to the gate input turns Q18 on and Q17 off by biasing the base of Q18 positive with respect to the base of Q17. Transistor Q18 stays on as long as the positive gate voltage is present. Negative pulses from the Schmitt trigger have no effect on the circuit in this state and the driving triggers from the delay one-shot are turned off until the gate voltage subsides. The positive and negative clamp levels of CR83 through CR86 protect against excessive gate voltages in addition to providing bias for the base of Q18.

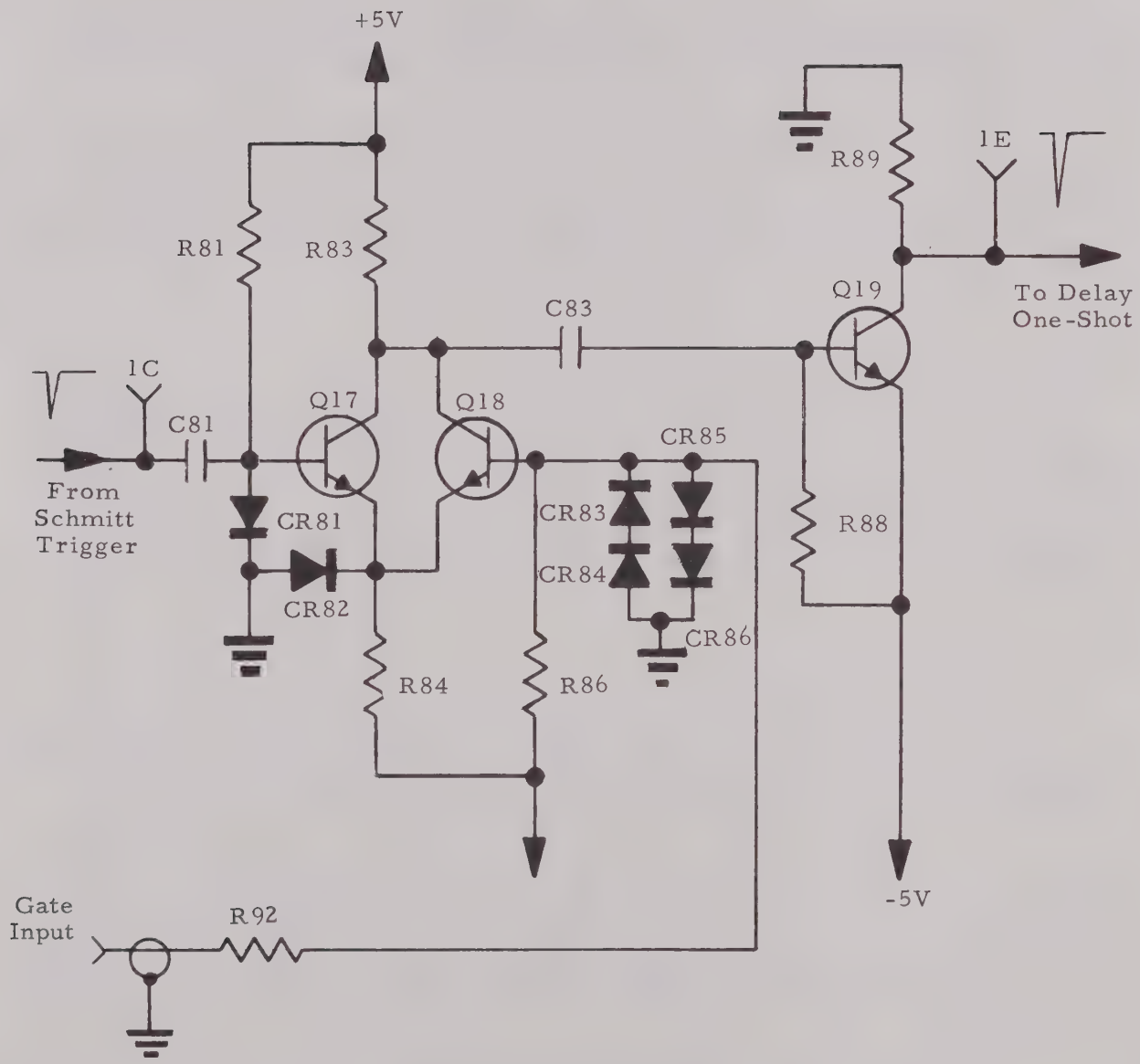


Figure 3-4. Gating Amplifier.

3.2.7 Delay One-Shot

The basic circuit of the delay one-shot is an emitter coupled multivibrator comprised of transistors Q20, Q21, and Q24 in Figure 3-5. The positive bias of diode CR101 and the negative bias of CR106 keep transistor Q20 on and Q21 off when there is no trigger signal from the gating amplifier. A negative pulse applied to its base by capacitor C102 cuts Q20 off and causes its collector voltage to rise. The positive transient is applied to timing capacitor C_T through emitter follower Q24 and coupled to the base of Q21. This feedback holds Q21 on and Q20 off while C_T charges through timing resistor R116. The emitter of Q21 follows its negative going base and when the voltage drops to the threshold established by CR101, Q20 turns on again to return the circuit to its quiescent state. Values of C_T are selected by the range switch and R116 is the continuously variable vernier for the pulse delay controls.

Tunnel diodes CR104 and CR105 produce rectangular positive and negative pulses in the collector circuits of Q20 and Q21, respectively, for the duration of the delay interval. The leading edge of the positive pulse and the positive going trailing edge of the negative pulse are differentiated by RC circuits and amplified by Q22 and Q23. Negative trigger pulses occur at emitter follower Q25 and are coupled to the width one-shot circuit through C141. In the single pulse mode of operation, the trigger pulse at the beginning of the delay interval is inhibited by holding CR104 in its high voltage state and the width one-shot is triggered only by the pulse at the end of the delay interval. Diode CR103 operates in conjunction with resistor R106 to protect the tunnel diodes against overload current in the event that the anode of either tunnel diode is accidentally grounded.

3.2.8 Width One-Shot

The tunnel diode edge shaper shown as a separate circuit in the block diagram is part of the width output circuit. The width one-shot circuit is composed of transistors Q26, Q27, and Q29 and tunnel diode CR144 in schematic diagram 40000-170.

Operation of the width one-shot circuit is identical to the delay one-shot described in the previous section except for its output coupling circuit. Tunnel diode CR144 in the collector circuit of Q26 provides a rectangular positive pulse with a duration determined by the pulse width controls. The leading and trailing edges of the pulse are differentiated by resistor R147 and capacitor C144 and coupled to the isolated circuit board by pulse transformer T301.

3.2.9 Schmitt Trigger Flip-Flop

In schematic diagram 40000-171, the circuit of Q301 and Q302 comprises a buffer amplifier, Q201 and Q202 a Schmitt trigger, and Q203 and Q204

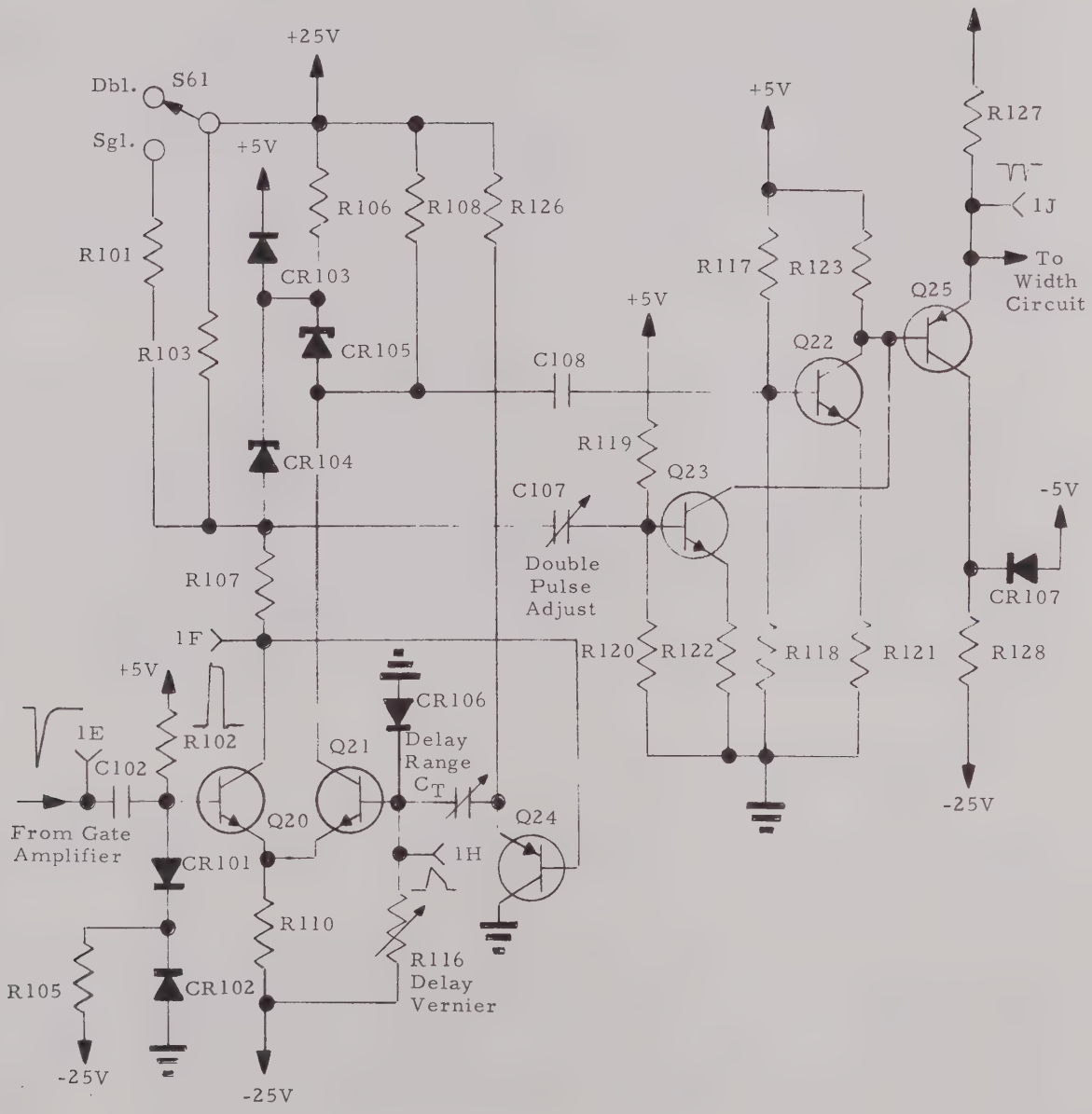


Figure 3-5. Delay One-Shot.

a complementary emitter follower. Leading and trailing edge triggers from the width circuit are differentiated by pulse shaping stub ST301 and coupled to the Schmitt trigger by the buffer amplifier. The negative leading edge trigger turns Q201 on and Q202 off, and the positive trailing edge trigger returns the circuit to the quiescent state at a time determined by the width controls. Both positive and negative drive for the rise and fall circuit are provided by the complementary emitter follower.

3.2.10 Rise and Fall Circuit

The rise and fall circuit, composed of transistors Q305 through Q308 in schematic diagram 40000-171, controls the transition time for the leading and trailing edges of the main output pulse. Linear transition times are obtained by charging and discharging a capacitor from separate constant current sources. The basic circuit consists of two differential amplifiers with common collector circuits. Transistors Q306 and Q308 comprise the rise circuit and Q305 and Q307 the fall circuit.

In the absence of a pulse from the Schmitt trigger flip-flop, diode CR304 conducts through resistor R318 and CR305 conducts through R320. The bias established by these diodes holds Q305 off and Q306 on, so that Q307 is on and Q308 is off. The leading edge of the negative pulse applied simultaneously to the bases of Q305 and Q306 reverses the state of both differential amplifiers. Transistors Q305 and Q308 remain on for the duration of the pulse and are restored to their original off state by the trailing edge of the pulse.

In the fast range (2-50 nanoseconds), the stray capacitance in the common collector circuit of Q307 and Q308 is alternately charged through Q308 to establish the rise time and discharged through Q307 for the fall time. The slow transition time range (50-500 nanoseconds) is selected by simultaneously switching capacitor C322 into the common collector circuit, and fixed resistors R332 and R327 into both the rise and fall current source circuits. Transistor Q312, in series with C322, is a local switch for front panel range switch S301. The leading and trailing edges are adjusted separately in each range by the vernier control of variable resistors R331A and R328A, respectively.

The booster circuit, comprised of Q309 and Q310, is included to decrease the minimum rise time. The two-stage amplifier of Q309 and Q310 applies a sharp negative current spike to the emitter of Q308 in response to the negative signal applied to the base of Q309 by the leading edge of the pulse. The rise time is decreased because this burst of current reduces the time required to charge the stray capacitance. This occurs only when the rise time control is set to minimum (fully counterclockwise) because of the emitter bias on Q310.

The pulse baseline is clamped to ground potential by returning the quiescent current in the collector of Q307 to ground through diode CR314 and the compensating circuit containing CR311. The voltage drop in CR314, that varies with its current, is cancelled by the drop in CR311. Transistors Q333 and Q334 comprise an emitter follower pair that has high current gain and presents a low impedance to clamp diode CR314. Diode CR312 provides temperature compensation for the base-emitter junction of Q333. The voltage drop in CR311 is controlled by rise/fall range switch S301 and variable resistor R328B ganged to the fall time vernier. Similarly, the pulse tops are clamped to V_{CL} by returning the current in the collector of Q308 to ground through clamp diode CR313 and compensating diode CR356 in the amplitude control circuit.

3.2.11 Output Amplifier

The basic circuit shown in Figure 3-6 is a current amplifier with its output stages operated between cutoff and the threshold of saturation for all levels of pulse amplitude and baseline offset. This provides flat pulse tops for all control settings because the gain-bandwidth of output amplifiers Q317 and Q318 is greatly reduced near saturation. Pulse aberration is minimized and variations that would tend to occur during the pulse interval are damped by the output transistors themselves. Operating voltages V_B and V_C, that track the pulse amplitude vernier setting and the baseline offset voltage, keep the output transistors at the same operating point for all pulse settings.

Transistors Q314, Q315, and Q316 comprise a two stage current amplifier that drives output amplifiers Q317 and Q318. Zener diode CR351 provides the voltage for the emitters of Q314 through Q316 that follows their collector voltage (V_C) to maintain constant operating conditions. Diodes CR352 through CR355 compensate for the voltage drop in clamp diode CR350 and transistors Q313 through Q316. This holds the emitters of Q317 and Q318 one diode drop beyond cutoff in the quiescent state. Emitter follower Q313 provides a low impedance voltage source for CR350.

The output of the rise and fall circuit is coupled to the output amplifier by emitter follower Q311 and capacitors C352 and C353. The capacitors permit the output amplifier to follow the baseline offset voltage with no alteration of its operating conditions. Quiescently, Q317 and Q318 are biased just beyond cutoff. A negative pulse at the base of Q314 is amplified and reproduced at the emitters of Q315 and Q316. This pulse drives Q317 and Q318 into conduction and to the threshold of saturation at a slope determined by the rise time controls. The output amplifiers are returned to cutoff by the trailing edge of the pulse at a slope determined by the fall time controls.

The main output pulse is applied to the T-pad attenuator through polarity switch S451 and toroidal balun T450. It is switched from negative to positive by inverting the polarity of the isolated circuit board with respect to chassis ground and using the isolated ground as the positive output. Floating power supplies are used for the output circuits and pulse transformer T301 provides isolation from

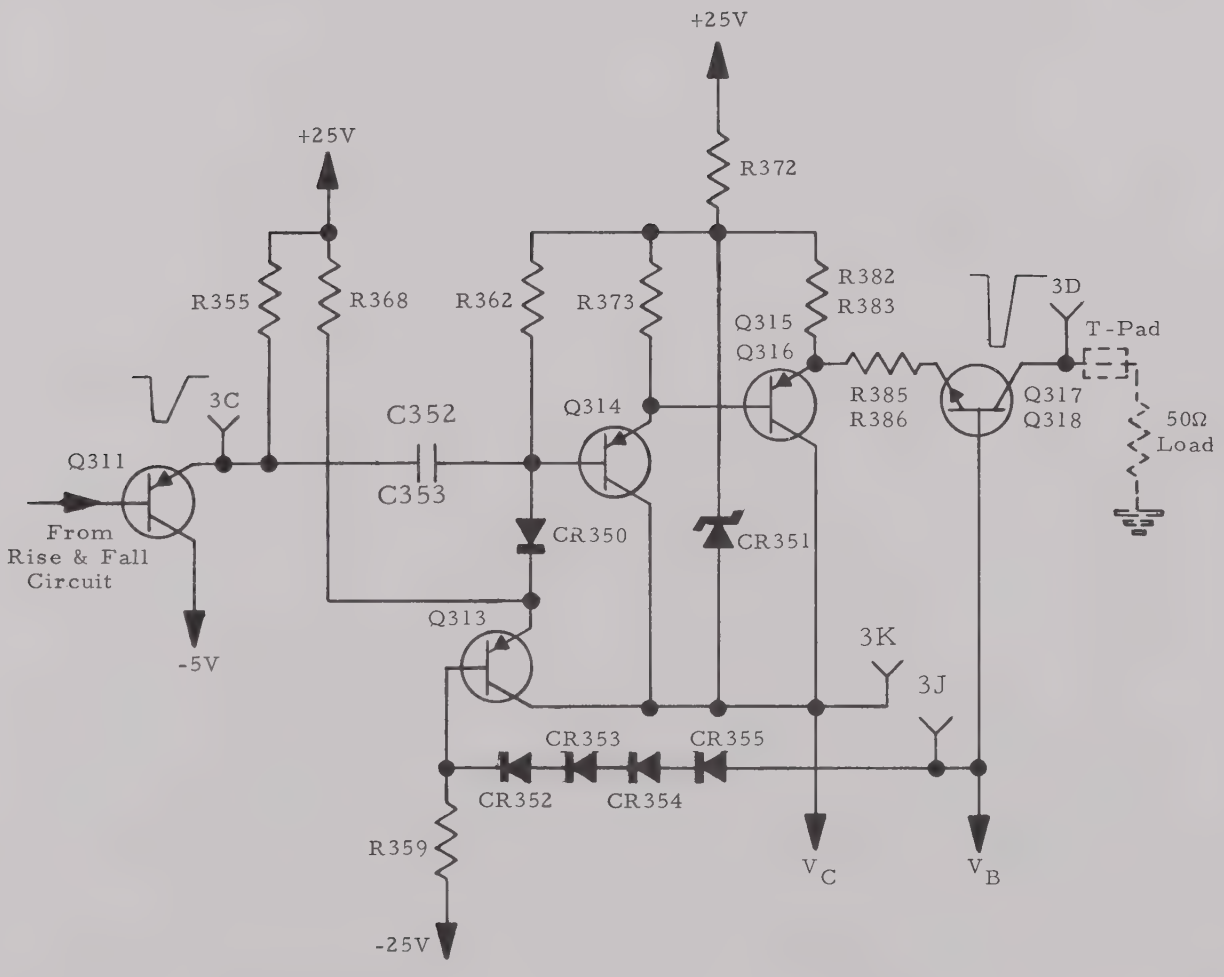


Figure 3-6. Output Amplifier.

the front end circuits. The toroidal balun isolates the capacitance between the isolated circuit board and the instrument chassis to prevent it from loading the positive pulse.

The attenuator is a three-step constant impedance T-pad. Continuously variable vernier control for each range is achieved by adjusting the pulse top voltage supplied to the rise and fall circuit from the amplitude control circuit. Thus the rise and fall slopes remain constant when the vernier is used for attenuation while the transition time is fixed and the slope changes when the amplitude range switch is used.

3.2.12 Amplitude Control

The amplitude control circuit, shown in simplified form in Figure 3-7, supplies the output amplifier circuit with operating voltages V_B and V_C that track the sum of the baseline dc level and the pulse amplitude control voltages. It also supplies variable pulse top voltage V_{CL} to the rise and fall circuit for vernier control of main pulse amplitude.

Potentiometer R352 provides continuously variable vernier control of pulse amplitude for each range by setting the pulse top voltage of the rise and fall circuit. Variations in V_{CL} are proportional rather than equal to pulse amplitude changes because of voltage gain in the output amplifier, and the factor of proportionality is set by V_{CL} tracking potentiometer R358. The circuit containing Q332, CR356 and R331B compensates for the variable voltage drop in diode CR313 in the rise and fall circuit by supplying CR356 with a variable current that follows current fluctuations in CR313. Potentiometers R375 and R367 (2-50 and 50-500 drives) provide separate calibration adjustments of V_{CL} on the slow and fast transition time ranges. Q335 and Q336 comprise an emitter follower pair with high current gain and low output impedance for the pulse amplitude voltage.

The circuit containing Q323 through Q326 and Q329 is a summing amplifier that generates V_B by adding the baseline offset and the pulse amplitude voltages. The circuit consisting of Q319 through Q322 is a memory amplifier that senses the baseline offset voltage and applies it to the summing amplifier. Zener diode CR405 holds V_C ten volts below V_B. The voltages are coupled to the output amplifier by high-current-gain emitter follower pairs consisting of Q327 and Q328 for V_B, and Q330 and Q331 for V_C.

3.2.13 Baseline dc Level

The baseline dc level circuit of schematic diagram 40000-172 is a dc voltage regulator with either a positive or a negative variable output. Front panel jacks permit it to be used as an auxiliary power supply or a constant-voltage load when it is not being used for baseline offset.

The error detector circuit of Q337 through Q340 simultaneously senses the voltage set by the dc level control and the baseline (or auxiliary output)

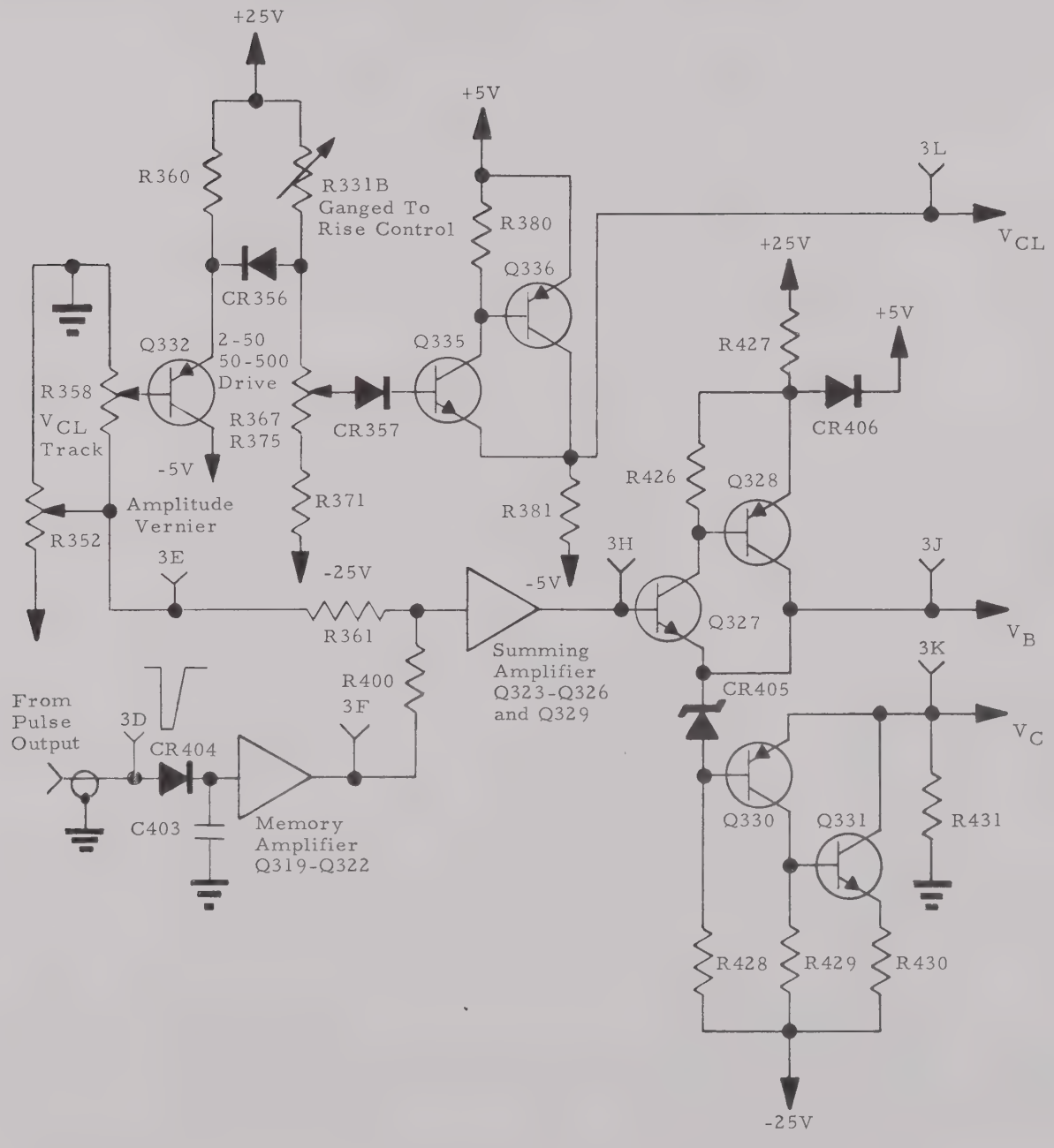


Figure 3-7. Amplitude Control.

voltage. Any difference in the two voltages causes the error detector to generate an amplified error signal that is applied to output drivers Q341 through Q344. The response of the drivers corrects the baseline offset voltage and keeps it equal to the dc level setting, independent of load circuit changes.

3.2.14 Power Supplies

Regulated dc voltages for the unit are provided by the two identical power supplies of schematic diagrams 40000-155 and 40000-156. One supply is floating to provide operating voltages for the isolated circuits and the other is grounded to the instrument chassis. Each supply has two identical rectifier and series regulator circuits for the positive and negative 25 volt outputs and mirror image shunt regulators for the 5 volt outputs.

The primary circuits of transformer T501 for the grounded supply, and T601 for the floating supply, are fused by F501. Both transformers are energized by power switch S501, and 115/230 line voltage selection is provided by switch S502. Each transformer has two secondaries connected to full wave bridge rectifiers for positive and negative outputs. The rectifier for the positive regulator of the grounded supply consists of diodes CR501 through CR504 and its output is filtered by capacitor C501. Transistors Q501 through Q506 and zener diode CR505 comprise the series regulator circuit. The 5 volt shunt regulator is composed of Q507 through Q510 and CR506 and CR507.

A voltage proportional to the output is provided by the voltage divider containing potentiometer R512 and is compared to the reference voltage of CR505 by the differential amplifier of Q501 and Q502. Any difference between the two voltages is amplified by Q503 and applied to the base of the high-current-gain Darlington pair of Q504 and Q505. The Darlington pair provides series regulation for the +25 volt output, in response to the error signal, by changing its output to eliminate the difference between the two sensed voltages.

Overload currents increase the voltage drop in series resistor R508 until the base of current limiter Q506 is forward biased. This turns Q506 on and prevents excessive currents because the base of the Darlington pair is back biased when Q506 conducts.

The reference voltage for the +5 volt supply is provided by the voltage divider containing potentiometer R515. The output voltage is compared to this reference by the differential amplifier of Q507 and Q508 which detects and amplifies any difference between the two. In response to an error signal at its base, Q509 applies a signal to the base of shunt regulator Q510 which adjusts the output voltage to reduce the error signal.

Diodes CR506 and CR507 are voltage clamps that raise the operating level of Q509 above ground. C503, C504, and C506 are filter capacitors and C505 is an oscillation suppressor. Capacitor C502 speeds up the response of the feed-

back control system for the 25 volt supply and reduces the ripple voltage by returning it to the differential amplifier as an error signal.

The operation of all four 25 volt regulators is identical with reference to the corresponding components. The operation of all four 5 volt supplies is similar except that the negative supplies are the mirror image of the positive supplies and have complementary transistors.

SECTION IV

MAINTENANCE

4.1 Preventive Maintenance

Proper care and correct use with regularly scheduled inspections provide the best protection against unnecessary repairs and down time. The Datapulse Model 111 is a sensitive laboratory instrument and should not be exposed to severe environmental conditions either in use or in storage. Contaminating or damaging exposure must be avoided at all times if long life and uninterrupted service are expected.

4.1.1 Inspection

Remove the top and bottom covers by loosening the four quarter-turn fasteners on each cover. The perforated side panels should normally be left on but may be taken off by removing two screws (each panel). Inspect for dirt and corrosion and for loose, broken, or burnt parts and wiring. Circuit board discoloration caused by heat may usually be disregarded unless the unit is inoperative. Inspection intervals should be based on frequency of use and the severity of the environment to which the unit is exposed.

4.1.2 Cleaning

Accumulated dust and dirt should be removed as often as required. Use either low velocity dry air or a soft nonmetallic brush to clear the interior of foreign matter. Clean dirty parts with a solvent such as trichlorethylene, using a soft cloth or a cotton tipped applicator for narrow spaces.

4.1.3 Recalibration

The instrument is correctly calibrated when it leaves the factory. However, calibration should be checked at regularly scheduled intervals of either accumulated operating hours or calendar time; 500 operating hours or six-month intervals are recommended. Refer to section 4.4 for complete calibration instructions.

4.2 Parts Replacement

A procedure should be carefully thought out before a part is removed to avoid unnecessary disassembly and accidental damage. Use only direct replace-

ments for parts affecting performance. Transistors temporarily removed should be returned to their original sockets unless defective. Replacement of some parts will necessitate partial recalibration.

4.2.1 Power Transistors

The power transistors for the dc power supplies are mounted on heat sinks. Fiber bushings and mica washers are used to electrically insulate the case (collector) from the heat sink (ground) and a thin film of silicon grease (such as Dow Corning DC-4) is applied to both sides of the mica washers to insure proper thermal conductivity. Incorrectly installed, the transistors may either short out or overheat and fail.

4.2.2 Soldering

Only experienced technicians should replace soldered parts. Printed circuits are vulnerable to excess heat as are many diodes and transistors. The following recommendations should be taken into consideration when replacing soldered parts:

a. Use small diameter rosin core solder and a 35 to 40 watt iron with a wedge or pointed tip, 1/16 to 1/8 inch wide. The tip must be clean and properly tinned with excess solder removed.

b. Obviously defective parts may be clipped out so their leads can be conveniently unsoldered from the board.

c. Solder only on the circuit side of the board; not on the component side.

d. Apply the tip of the iron directly to the solder joint, at the eyelet, just long enough for the solder to flow.

e. Avoid bringing the iron into contact with the circuit board; overheating will cause the conductor to lift from the board.

f. Use a solder sipper (or some other means) to remove excess solder first when unsoldering a lead, particularly where a lead is bent over so that it can be straightened before it is pulled out.

g. When a lead is free, clean the hole and remove excess solder, using a solder sipper or a sharp object such as a toothpick or pointed tool.

h. To prevent heat damage when soldering heat sensitive components, use a heat sink or long nose pliers to grip the lead between the part and the board.

i. Leave a small space between the circuit board and the part when soldering heat dissipating components such as resistors.

j. Clean the area thoroughly after soldering.

4.2.3 Selected Components

In some cases the value of a component is selected in production to avoid the use of a calibration adjustment. These components are marked with an asterisk on the schematic diagram, and it should not be necessary to alter their values throughout the life of the instrument. If replacement of a damaged part does not restore proper operation of the instrument, the factory or nearest Datapulse representative should be contacted for assistance.

4.3 Troubleshooting

Before concluding that an instrument is in need of repair, be sure it is being operated correctly and that it is not out of calibration. Check for faulty operation by following the steps of section 2.2, and use the procedure in section 4.4 to verify calibration. A replaced or aging component may cause an apparent malfunction that is readily corrected by a calibration adjustment. Test equipment and connectors are frequent sources of trouble and should be double checked before deciding that the instrument is at fault.

A unit that is operating incorrectly should be thoroughly inspected for obvious or apparent damage before its circuits are checked. When neither the instrument nor its pilot lamp will go on the trouble is probably in the input power circuit. The power supply quiescent outputs and ripple voltages should be checked before the pulse forming circuits are suspected.

4.3.1 Input Power Circuit

A general purpose volt-ohm-meter is required for the following checks:

a. Make sure that line cord is correctly connected and making contact with the power source connector.

b. Remove the fuse from the back panel and check it for continuity. Replace the fuse.

c. Measure the line voltage at the source and check for agreement with the voltage set on the rear panel slide switch.

d. Remove the top and bottom covers and check for line voltage at the inputs to the power transformers with the POWER switch ON;

check between test points CB and CE for 230 volt inputs and between CB and CC or CD and CE for 115 volt inputs.

e. Measure the secondary voltages at nominal line voltage (117 or 234 volts). Verify approximately 32 volts between test points CF and CH, and between CJ and CK for the grounded power supply. Verify approximately 37.5 volts between points DA and DB, and between DC and DD for the isolated power supply.

4.3.2 Power Supplies

CAUTION

Make sure the PULSE POLARITY switch is on (-) before making any measurements or adjustments; in the (+) position, the isolated power supply ground is floating and the output circuits are inverted with respect to chassis ground.

a. With the REPETITION RATE selector on SINGLE CYCLE, measure the dc outputs of both supplies. Test points are labeled and have small metal loops for convenient connections. Adjustment accuracies are 1% or better (refer to section 4.4, Calibration).

1. For the grounded power supply, measure between chassis ground and test point 5D (+25V), 5E (+5V), 5K (-25V), and 5L (-5V).

2. For the isolated supply, measure between its ground and test point 6D (+25V), 6E (+5V), 6K (-25V), and 6L (-5V).

b. Use an oscilloscope (or any other suitable means) to measure the quiescent ripple voltage of each dc output (with the REPETITION RATE selector on SINGLE CYCLE). It should be less than 2 millivolts peak-to-peak for all outputs.

c. Measure the unregulated dc outputs of the two bridge rectifiers in each power supply at nominal line voltage.

1. Verify approximately 40 volts dc between test point 5A (+) and chassis ground (-), and between 5F (+) and 5K (-) for the grounded supply.

2. Verify approximately 46 volts dc between DE (+) and DF (-), and between DH (+) and DJ (-) for the isolated supply.

d. For problems in the regulator circuits, refer to the schematic diagrams (drawings no. 40000-155 and -156) and paragraph 3.2.14 in the Theory of Operation, and make a point to point check of circuits in question. Transistor locations are marked on the bottom of the grounded supply circuit board and on top of the isolated supply board. The power transistors are on heat sinks, on the back panel for the grounded supply, and between the back panel and its circuit board for the isolated supply.

NOTE: Most power supply failures are caused by collector-to-emitter shorts in transistors and anode-to-cathode shorts in rectifiers and zener diodes. A shorted semiconductor will exhibit low resistance in both directions.

4.3.3 Pulse Circuits

After verifying that the power supply is operating correctly, the remaining circuits should be inspected again for visual damage that may have been overlooked. The functional nature of the problem as revealed by an operational check (section 2.2) will usually cast suspicion on a particular circuit. A double check of calibration adjustments (section 4.4) should be made before a circuit is condemned.

NOTE: It should not be assumed that the replacement of an obviously defective component will completely solve a problem until it has been verified that the replaced part is the actual cause and not the result of a more basic problem.

The best approach to troubleshooting a circuit is to gain a thorough understanding of its operation and then systematically isolate the problem. A probable cause may be anticipated by a study of the schematic diagrams (drawings 40000-170 and -171) and the Theory of Operation. Circuits in question should be located schematically and then logically related to the problem by the Theory of Operation. A comparison of the waveforms on the schematics and Figure 3-1 to the actual test point waveforms provides a helpful guide in isolating trouble in the pulse circuits (be sure the control settings are the same as those given for Figure 3-1).

4.3.4 Baseline dc Level

The baseline offset circuit illustrated in schematic number 40000-172 is mounted on the left of the isolated power supply, on the same circuit board. It is basically a voltage regulator (described in paragraph 3.2.13 of the Theory of Operation) with either a positive or negative output that follows its variable input. To quickly check its operation, connect dc voltmeters from the GRD (ground) jack to the DC LEVEL MONITOR (input) and AUX PWR OUTPUT jacks with the MODE switch on AUX PWR. Then verify that the output tracks the

input as the DC LEVEL control is turned through its range for both positions of the POLARITY switch. As in the case of the pulse forming circuit, a problem can be isolated by logically relating it to a particular component or sub-circuit through a study of the circuit and its theory.

4.4 Calibration

Calibration adjustments should be made only when necessary and only when instruments with the required accuracies are available. Adjustments are limited to the accuracies of the calibrating instrument which is typically ±3% for most oscilloscopes and general purpose voltmeters. An actual error of 1% may appear to be 4% on an instrument that is 3% off in the same direction.

The steps in this procedure are arranged in proper sequence for a complete calibration of the instrument and should be followed in this order. The power supplies in particular should be calibrated first. However, complete instrument control setting instruction is given in each section so that individual adjustments can be made when necessary. Refer to Figures 4-1 and 4-2 for the location of calibration controls.

CAUTION

Make sure the PULSE POLARITY switch is in the (-) position before making any measurements or adjustments; in the (+) position, the isolated power supply ground is floating and the output circuits are inverted with respect to chassis ground.

4.4.1 Equipment (or equivalent) Required

a. A multiple range dc voltmeter with an accuracy of 0.1% such as a digital or differential voltmeter.

b. A general purpose oscilloscope of at least 15 megahertz bandpass with triggered sweep and a 10:1 attenuator probe.

c. A sampling oscilloscope with a rise time of 0.4 nanoseconds or less and a probe with an input impedance of at least 5,000 ohms (preferably with 100:1 attenuation such as a Tektronix No. P6035).

d. A 50 ohm, 10:1 (20 dB) coaxial attenuator capable of 2 watts dissipation.

NOTE: Standard one-watt attenuators are adequate for most combinations of control settings but should be used with care. Pulse output power approaches 2 watts for high duty cycle waveforms when the dc level and the pulse amplitude are maximum and the same polarity.

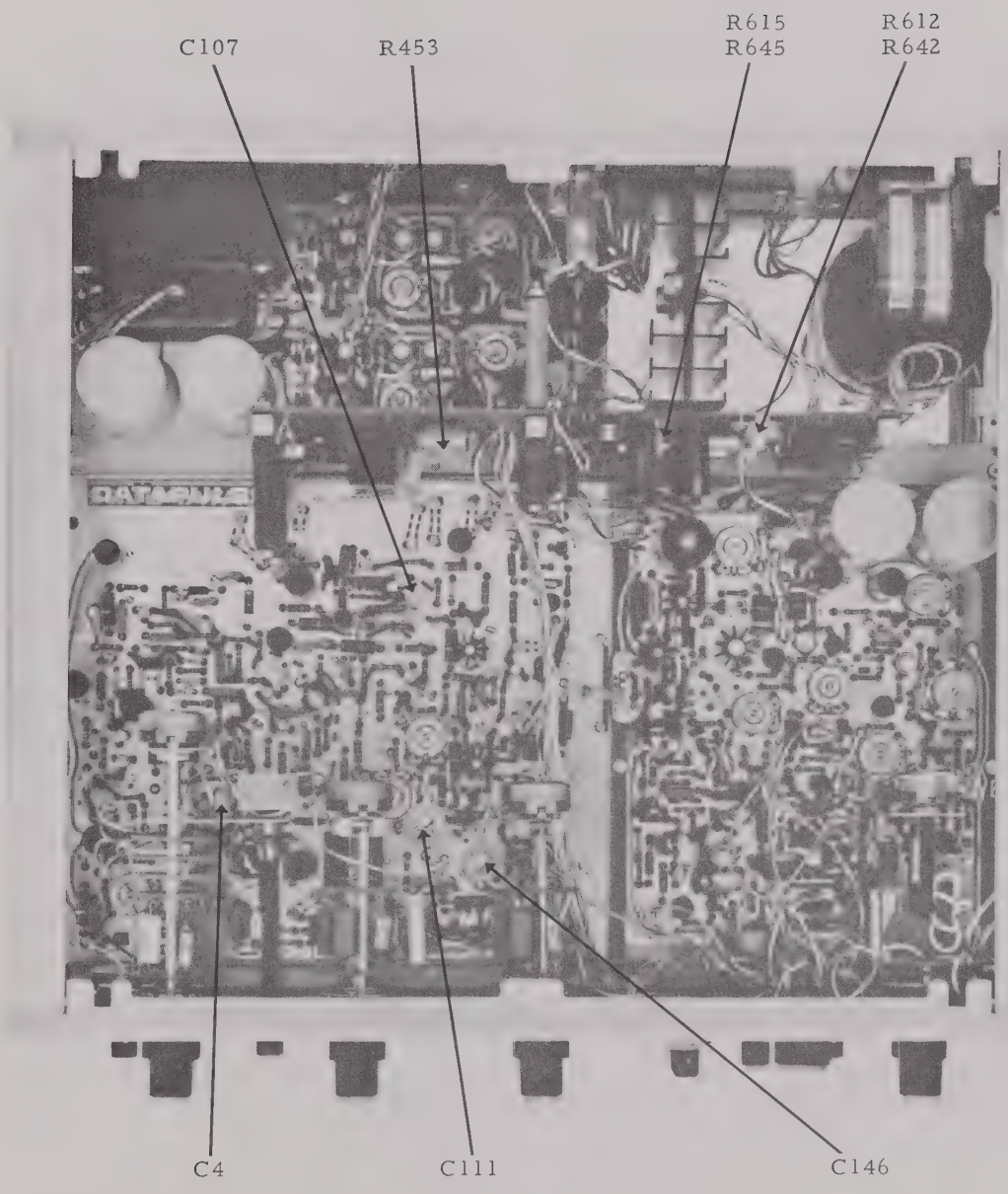


Figure 4-1. Top View — Model 111.

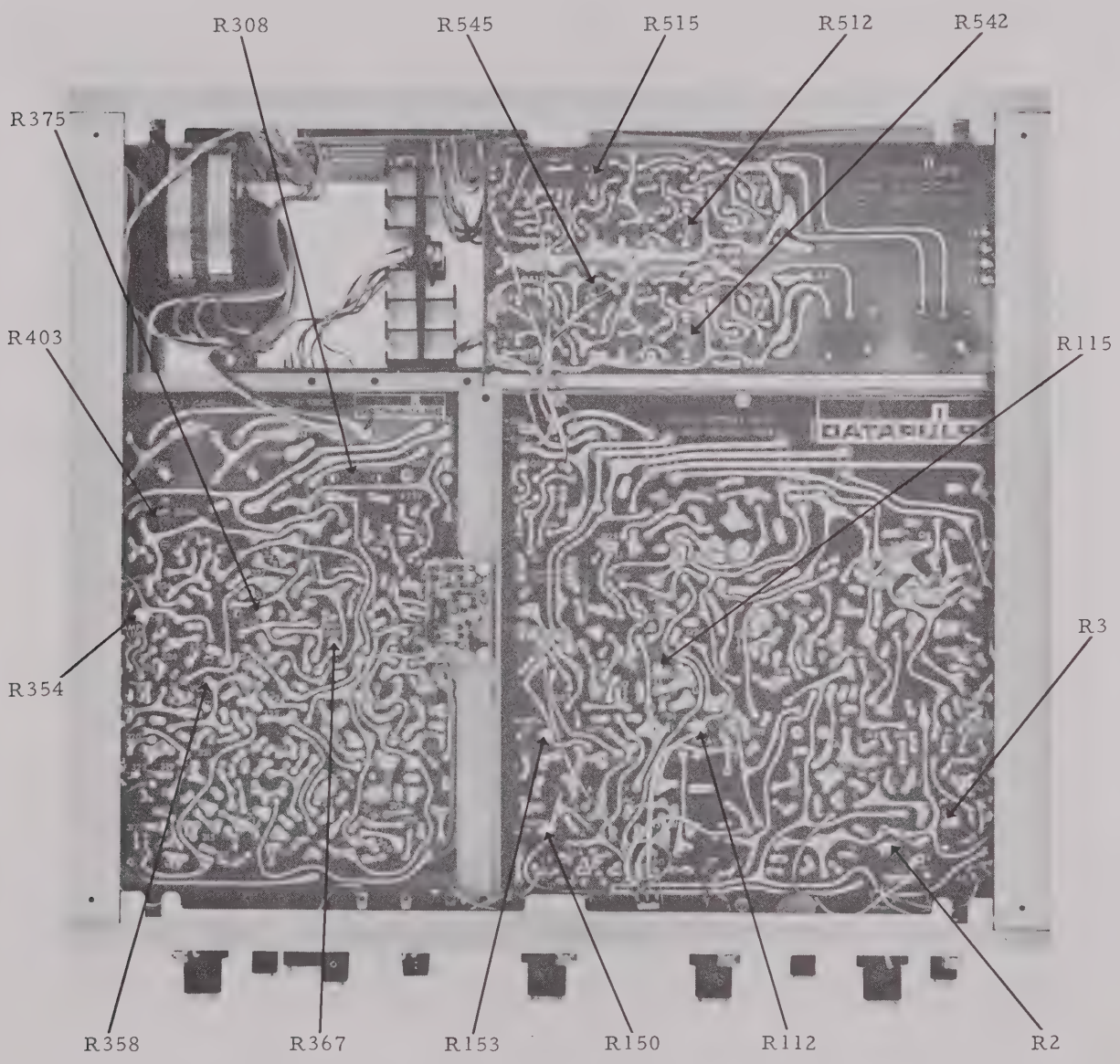


Figure 4-2. Bottom View — Model 111.

e. A 50 ohm, 1/2 watt, 10:1 coaxial attenuator such as a Tektronix No. 011-059 T-Pad.

f. An rms reading ac voltmeter, 0-150 volts (or 300 volts for 230 line voltage).

g. A variable line autotransformer with at least 1.5 ampere capacity.

h. Two 50 ohm coaxial cables with BNC connectors.

4.4.2 Grounded Power Supply Calibration

The grounded power supply circuit board is in the left rear corner and is accessible with the bottom cover removed. Test points and calibration controls are labeled and the test points have small metal loops for convenient connection.

When troubleshooting a malfunctional instrument, the ripple voltage should be checked on the general purpose oscilloscope (or any other suitable instrument) before changing any dc voltage setting. It should be less than 2 millivolts peak-to-peak for the 25 volt outputs and less than 1 millivolt peak-to-peak for the 5 volt outputs measured at the power supply test points. The REPETITION RATE selector must be in the SINGLE CYCLE position for ripple measurements.

a. Connect the autotransformer to a suitable ac power source.

CAUTION

Check the position of the 115/230 volt slide switch on the back of the unit for agreement with the line voltage before connecting the power cord.

b. Connect the pulse generator and the ac voltmeter to the autotransformer and set the transformer for nominal line voltage (117 or 234 volts).

c. Set the instrument controls as follows:

Control	Setting
REPETITION RATE selector	SINGLE CYCLE
AMPLITUDE selector	1.5 VOLTS
PULSE POLARITY switch	(-)
POWER switch	ON
Remaining controls	any position

d. Connect the dc voltmeter (set to an appropriate scale) between test point 5D (+25 volts) and GRD. Use a small screwdriver to set the +25V ADJ control (R512 on schematic diagram 40000-155) for 25 volts ±1 volt. Vary the line voltage ±10% and verify regulation (dc voltage does not vary more than ±25 millivolts).

e. Connect the dc voltmeter between test point 5K (-25 volts) and GRD. Set the -25V ADJ control (R542) for 25 volts ±1 volt. Vary the line voltage ±10% and verify regulation.

f. Connect the dc voltmeter between test point 5E (+5 volts) and GRD. Set the +5V ADJ control (R515) for 5 volts ±50 millivolts.

g. Connect the dc voltmeter between test point 5L (-5 volts) and GRD. Set the -5V ADJ control (R545) for 5 volts ±50 millivolts.

4.4.3 Isolated Power Supply Calibration

The isolated power supply circuit board (identical to the grounded power supply board) is mounted vertically, parallel to the back, on the right side, and is accessible with the top cover removed. Calibration controls and test points are labeled on the component (front) side.

a. With the autotransformer set for nominal line voltage, set the instrument controls as follows:

Control	Setting
REPETITION RATE selector	SINGLE CYCLE
AMPLITUDE selector	1.5 VOLTS
PULSE POLARITY switch	(-)
Remaining controls	any position

b. Connect the dc voltmeter between test point 6D (+25 volts) and GRD (on the isolated power supply board). Set the +25V ADJ control (R612 on schematic diagram 40000-156) for 25 volts ±1 volt. Vary the line voltage ±10% and verify regulation.

c. Connect the dc voltmeter between test point 6K (-25 volts) and GRD. Set the -25V ADJ control (R642) for 25 volts ±1 volt. Vary the line voltage ±10% and verify regulation.

d. Connect the dc voltmeter between test point 6E (+5 volts) and GRD. Set the +5V ADJ control (R615) for 5 volts ±50 millivolts.

e. Connect the dc voltmeter between test point 6L (-5 volts) and GRD. Set the -5V ADJ control (R645) for 5 volts ±50 millivolts.

4.4.4 Amplifier Zero Calibration

The amplifier zero adjustment control is on the output amplifier and amplitude control circuit board which is in the right front corner of the unit. Calibration controls and test points with small metal loops for convenient connection are labeled and are accessible with the bottom cover removed. Ground points that also have connection loops are provided close to each test point and can be identified by their small rectangular tabs.

a. Set the instrument controls as follows:

Control	Setting
REPETITION RATE selector	SINGLE CYCLE
DC LEVEL MODE switch	PULSE AT GRD
AMPLITUDE selector	1.5 VOLTS
AMPLITUDE vernier	midrange
PULSE POLARITY switch	(-)
Remaining controls	any position

b. Connect the dc voltmeter between test points 3E (AMPLITUDE potentiometer output) and 3J (tracking voltage V_B) and adjust the AMP ZERO control (R403 on schematic diagram 40000-171) for 0 volts ±10 millivolts.

4.4.5 Baseline dc Level Calibration

The dc level circuit board is mounted vertically on the left side of the isolated power supply circuit board and is accessible with the top cover removed.

a. With the autotransformer set for nominal line voltage, set the instrument controls as follows:

Control	Setting
REPETITION RATE selector	SINGLE CYCLE
DC LEVEL control	0 V
DC LEVEL POLARITY switch	ZERO
DC LEVEL MODE switch	PULSE OFFSET
AMPLITUDE selector	1.5 VOLTS
PULSE POLARITY switch	(-)
Remaining controls	any position

b. Connect the dc voltmeter between the PULSE OUTPUT connector and GRD and set the BASELINE BALANCE ADJ control (R453 on schematic diagram 40000-172) for 0 volts ±10 millivolts.

c. Set the DC LEVEL control to 5.00 volts, the DC LEVEL POLARITY to (+) and readjust the +5V ADJ potentiometer on the grounded power supply circuit board (R515 on schematic diagram 40000-155) for 5 volts ±10 millivolts.

d. Change the DC LEVEL POLARITY switch to (-) and readjust the -5V ADJ potentiometer (R545 in the grounded power supply circuit) for 5 volts ±10 millivolts.

4.4.6 Clock Generator Calibration

The clock generator circuit is on the front end circuit board which is in the left front corner of the unit. The upper and lower limit calibration controls are labeled OSC UL and OSC LL and are accessible with the bottom cover removed.

a. Synchronize the general purpose oscilloscope from the SYNC OUTPUT by means of a 50 ohm coaxial cable, and use the 10:1 attenuator probe to simultaneously monitor the SYNC OUTPUT.

b. Set the instrument controls as follows:

Control	Setting
REPETITION RATE selector	4 MHz
REPETITION RATE vernier	fully clockwise
AMPLITUDE selector	1.5 VOLTS
PULSE POLARITY switch	(-)
Remaining controls	any position

c. Adjust the oscilloscope controls for a convenient display and set the OSC UL control (R3 on schematic diagram 40000-170) for a frequency of 4 megahertz (250 nanosecond period).

d. Turn the vernier fully counterclockwise and adjust the OSC LL control (R2) for a frequency of 360 kilohertz (2.8 microsecond period) to provide 10% overlap on the lower limit.

e. Check the upper limit of each range (except the 4-40 MHz range) for the front panel frequency and the lower limit for overlap. Repeat steps (b) through (d) if necessary to get the optimum settings with full frequency coverage.

NOTE: If it is not possible to set the OSC UL and the OSC LL controls for overlap of all ranges, one or more of the timing capacitors (C6 through C11) may be out of tolerance.

4.4.7 Pulse Delay Calibration

The delay circuit is on the front end circuit board. All test points and the upper and lower limit calibration controls are labeled and are accessible from the bottom.

a. Synchronize the general purpose oscilloscope from the SYNC OUTPUT and use the 10:1 attenuator probe to monitor test point 1F.

b. Set the instrument controls as follows:

Control	Setting
REPETITION RATE controls	100 kilohertz
DELAY selector	5μs
DELAY vernier	fully counterclockwise
AMPLITUDE selector	1.5 VOLTS
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

c. Adjust the oscilloscope controls for a convenient display and set the DELAY LL control (R115 on schematic diagram 40000-170) for a pulse width of 0.45 microseconds.

d. Turn the DELAY vernier fully clockwise and set the DELAY UL control (R112) for a pulse width of 5.0 microseconds.

e. Check the upper limit of each range (except the 50 NS range) for the front panel delay and the lower limit for overlap. Repeat steps (b) through (d) if necessary to get the optimum settings with continuous full range coverage.

NOTE: If the DELAY UL and DELAY LL controls cannot be set for overlap of all ranges, one or more of the timing capacitors (C112 through C117) may be out of tolerance.

4.4.8 Pulse Width Calibration

The width circuit is on the front end circuit board. All test points and the upper and lower limit calibration controls are labeled and are accessible from the bottom.

a. Synchronize the general purpose oscilloscope from the SYNC OUTPUT and use the 10:1 attenuator probe to monitor test point 1K.

b. Set the instrument controls as follows:

Control	Setting
REPETITION RATE controls	100 kilohertz
DELAY controls	minimum delay
WIDTH selector	5μs
WIDTH vernier	fully counterclockwise
AMPLITUDE selector	1.5 VOLTS
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

c. Adjust the oscilloscope controls for a convenient display and set the WIDTH LL control (R153 on schematic diagram 40000-170) for a pulse width of 0.45 microseconds.

d. Turn the WIDTH vernier fully clockwise and set the WIDTH UL control (R150) for a pulse width of 5.0 microseconds.

e. Check the upper limit of each range (except the 50 NS range) for the front panel delay and the lower limit for overlap. Repeat steps (b) through (d) if necessary to get the optimum setting with continuous full range coverage.

NOTE: If the WIDTH UL and WIDTH LL controls cannot be set for overlap of all ranges, one or more of the timing capacitors (C147 through C150) may be out of tolerance.

4.4.9 Schmitt Trigger Flip-Flop Calibration

The threshold adjustment for the Schmitt Trigger Flip-Flop (R203 on schematic 40000-171) is on the small circuit board mounted between the front end and output amplifier circuit boards, and is adjusted from the bottom.

a. Set the instrument controls as follows:

Control	Setting
REPETITION RATE controls	1 KHz
DELAY controls	minimum
WIDTH controls	maximum
AMPLITUDE selector	1.5 VOLTS
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

b. Synchronize the general purpose oscilloscope from the SYNC OUTPUT and use the 10:1 attenuator probe to monitor test point 1K.

c. Adjust the oscilloscope controls for a convenient display with a single pulse on the oscilloscope trace. Then move the attenuator probe to test point 3B, adjusting threshold control R203 if necessary, and verify a negative replica of the positive pulse appearing at 1K.

d. Slowly turn threshold control R203 clockwise until the pulse collapses into the baseline, mark this position, and then back the control off slightly, until the pulse reappears (if the pulse did not disappear, leave the control in the fully clockwise position).

e. Turn the WIDTH controls to minimum, the REPETITION RATE selector to the 4-40 MHz range with the 4-40 MHz vernier fully counterclockwise, and the PULSE MODE switch to DOUBLE. Adjust the oscilloscope controls for a convenient display with a single pulse pair on the trace.

f. Turn R203 counterclockwise until the first pulse of the pulse pair starts to widen and merge with the second pulse. Set R203 midway between this position and the setting of step (d).

g. Adjust the 4-40 MHz vernier for a repetition rate of 25 megahertz, and set the oscilloscope controls so that a single pulse period appears on the trace. Simulate a repetition rate of 50 megahertz by turning the DELAY vernier clockwise to position the second pulse midway between the first pulse and the first pulse of the next pulse period.

h. If the control settings of step (g) cause the waveform of the second pulse to deteriorate, make a slight correction in the setting of R203 to eliminate the distortion, and then turn the 4-40 MHz and the DELAY verniers fully counterclockwise. If the first pulse again starts to widen and merge with the second, make a slight clockwise adjustment of R203 to restore the waveform to normal, and repeat step (g).

4.4.10 Pulse Drive and Amplitude Control Calibration

The amplitude limit adjustment, the V_{CL} tracking potentiometer, and the two potentiometers that balance the pulse drive for the 2-50 and 50-500 transition time ranges are on the output amplifier and amplitude control circuit board labeled AMP LIM, V_{CL}, 2-50, and 50-500, respectively.

a. Set the instrument controls as follows:

Control	Setting
REPETITION RATE selector	4 MHz
REPETITION RATE vernier	fully counterclockwise
DELAY controls	minimum

Control	Setting
WIDTH selector	500 NS
WIDTH vernier	midrange
DC LEVEL MODE switch	PULSE AT GRD
RISE/FALL selector	50-500 NS
RISE vernier	fully counterclockwise
FALL vernier	fully counterclockwise
AMPLITUDE selector	5.0 VOLTS
AMPLITUDE vernier	fully counterclockwise
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

b. Monitor the PULSE OUTPUT on the sampling oscilloscope using a 10:1 coaxial attenuator. Set the oscilloscope sweep speed to 50ns/cm with its vertical sensitivity set for 0.5V/cm, and trigger the oscilloscope externally from the SYNC OUTPUT using a 50 ohm coaxial cable and the 1/2 watt, 10:1 coaxial attenuator.

c. Adjust the 50-500 drive control (R367 on schematic 40000-171) for maximum amplitude and best waveform with a linear trailing edge, as shown in Figure 4-3a.

d. Turn the AMPLITUDE and FALL verniers fully clockwise, and set the oscilloscope for 0.2μs/cm and 1V/cm. Adjust the V_{CL} potentiometer (R358) for maximum amplitude and best waveform with a linear trailing edge, as shown in Figure 4-3b.

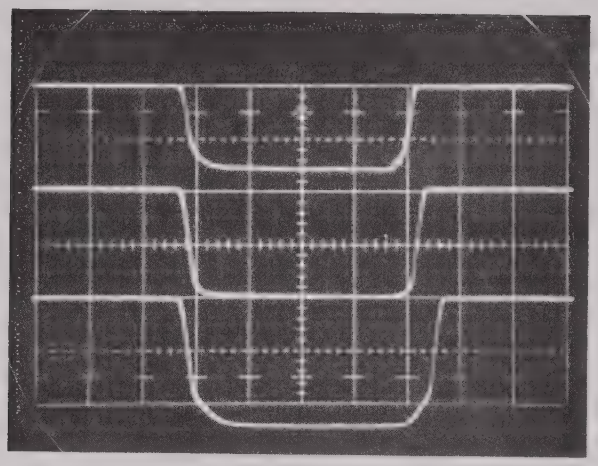
e. Turn the AMPLITUDE and FALL verniers fully counterclockwise and repeat steps (c) and (d) as necessary to get the optimum settings (the V_{CL} and drive controls interact).

NOTE: If it is not possible to get a good clean waveform, either the V_{CL} or 50-500 drive control may be faulty.

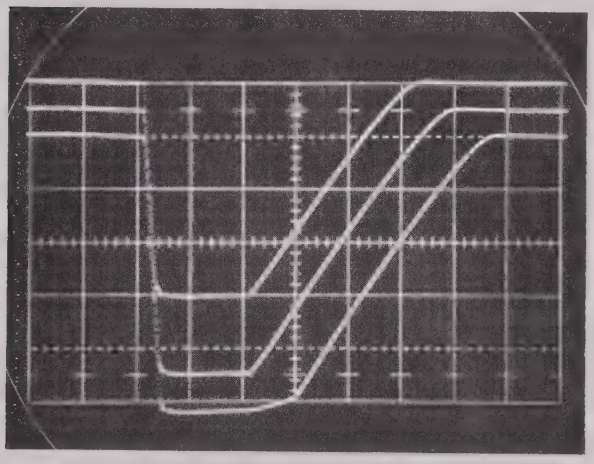
f. Turn the AMPLITUDE vernier fully counterclockwise and the FALL vernier fully clockwise. Turn the RISE/FALL selector to 2-50NS, and set the oscilloscope for 0.1μs/cm and 0.5V/cm. Adjust the 2-50 drive control (R375) for best waveform with a linear trailing edge, as shown in Figure 4-3c.

g. Turn the AMPLITUDE vernier fully clockwise, set the oscilloscope vertical sensitivity to 1V/cm, and adjust the V_{CL} control for best waveform with a linear trailing edge.

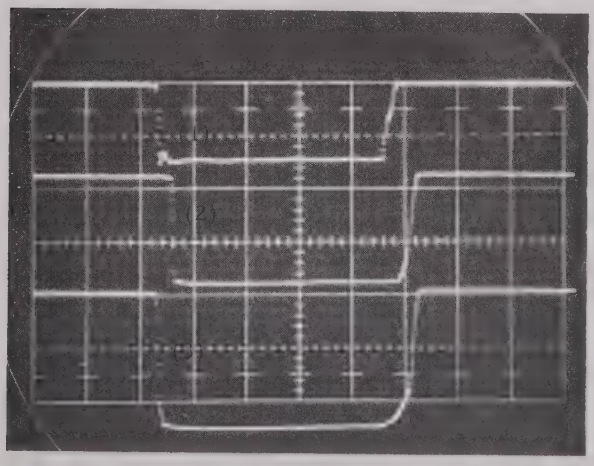
h. Adjust the AMP LIM control (R354) for a pulse amplitude of 5 volts.



a. 50-500 Adjustment. 50 ns/cm & 0.5 V/cm



b. V_{CL} Adjustment. 0.2µs/cm & 1 V/cm



c. 2-50 Adjustment. 0.1 µs/cm & 0.5 V/cm

Figure 4-3. Pulse Drive Calibration.

(1) Underdriven: CCW

(2) Correct Adjustment

(3) Overdriven: CW

4.4.11 Minimum Period, Delay, and Width Ranges Calibration

The minimum range calibration controls are trimmer capacitors mounted on top of the front end circuit board near their respective front panel controls. In schematic diagram 40000-170, they are designated as C4 for the maximum repetition rate (minimum period), C111 for the minimum delay, and C146 for the minimum width range.

a. Set the instrument controls as follows:

Control	Setting
REPETITION RATE selector	4-40 MHz
4-40 MHz vernier	fully clockwise
DELAY and WIDTH controls	minimum
DC LEVEL MODE switch	PULSE AT GRD
RISE and FALL controls	minimum
AMPLITUDE selector	1.5 VOLTS
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

b. Monitor the SYNC OUTPUT on the sampling oscilloscope using the test probe and set the oscilloscope controls for a convenient display [see note after step (b) of paragraph 4.4.9].

c. Adjust oscillator trimmer capacitor C4 for a frequency of 40 megahertz using an insulated screwdriver.

d. Turn the REPETITION RATE vernier fully counterclockwise and the DELAY vernier fully clockwise, and monitor test point 1F by means of the test probe.

e. Set the oscilloscope controls for a convenient display and use an insulated screwdriver to adjust delay trimmer capacitor C111 for a pulse width of 70 nanoseconds.

f. Turn the WIDTH vernier fully clockwise and monitor test point 1K with the test probe.

g. Set the oscilloscope controls for a convenient display and adjust width trimmer capacitor C146 for a pulse width of 50 nanoseconds using an insulated screwdriver.

4.4.12 Minimum Double Pulse Width Calibration

The double pulse width balance control is a small trimmer capacitor mounted on top of the front end circuit board near the center of the instrument (C107 in schematic 40000-170).

a. Set the instrument controls as follows:

Control	Setting
REPETITION RATE selector	4 MHz
REPETITION RATE vernier	fully clockwise
DELAY and WIDTH selectors	50 NS
DELAY vernier	fully clockwise
WIDTH vernier	fully counterclockwise
DC LEVEL MODE switch	PULSE AT GRD
RISE and FALL controls	minimum
AMPLITUDE selector	1.5 VOLTS
PULSE POLARITY switch	(-)
PULSE MODE switch	DOUBLE
Remaining controls	any position

b. Monitor the PULSE OUTPUT on the sampling oscilloscope using a 50 ohm coaxial cable and a 10:1 coaxial attenuator, and adjust the oscilloscope time position controls for a convenient display, with a single pulse pair on the trace.

c. Set the DELAY vernier for approximately 30 nanoseconds delay and use an insulated screwdriver to adjust the double pulse width trimmer capacitor so that the width of the first pulse is the same as the second.

4.5 Specification Verification

The purpose of the following procedure is to verify that the instrument performs as specified.

4.5.1 Equipment (or equivalent) Required

a. A general purpose oscilloscope of at least 15 megahertz bandpass with delayed sweep and a dual trace vertical amplifier.

b. A sampling oscilloscope with a rise time of 0.4 nanoseconds or less.

c. A variable frequency trigger (or pulse) generator capable of both positive and negative outputs at an amplitude of at least 2 volts into 500 ohms and frequencies up to 40 megahertz, such as a Datapulse Model 110B or Model 111.

d. A variable frequency square-wave generator with an output of at least 4 volts into 1000 ohms.

NOTE: Any Datapulse pulse generator will satisfy these requirements and the requirements of item (c) up to the limiting frequency of the instrument.

e. A 50 ohm coaxial termination with BNC connectors capable of 2 watts dissipation, such as a Datapulse Type 2003A Power Termination.

NOTE: A one watt termination is adequate for most combinations of control settings but must be used with care because pulse output power approaches 2 watts for high duty cycle waveforms when the dc level and the pulse amplitude are maximum and the same polarity.

f. A 50 ohm, 1/2 watt coaxial termination with BNC connectors.

g. A 50 ohm, 10:1 (20 dB) coaxial attenuator with BNC connectors capable of 2 watts dissipation [see note after step (e) above, if a lower wattage attenuator is used].

h. A 50 ohm, 10:1, 1/2 watt coaxial attenuator with BNC connectors.

NOTE: The attenuators are normally required because both the main pulse and trigger outputs exceed the maximum safe input voltages of many sampling oscilloscopes.

i. Three long (2-3 feet) and two short (3-9 inch) 50 ohm coaxial cables with BNC connectors and two BNC Tee connectors.

j. Two BNC to GR 874 connector adaptors.

4.5.2 Repetition Rate

CAUTION

Check the position of the 115/230 volt slide switch on the back panel for agreement with the line voltage before connecting the power cord.

a. Set the instrument controls as follows:

Control	Setting
REPETITION RATE selector	40 Hz
REPETITION RATE vernier	fully counterclockwise

Control	Setting
DELAY controls	minimum
WIDTH controls	maximum
DC LEVEL MODE switch	PULSE AT GRD
RISE/FALL controls	minimum
AMPLITUDE controls	maximum
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

b. Connect the instrument to a suitable power source, turn the POWER switch ON, and note that both the pilot and the TRIGGERED lamps go on.

c. Monitor the PULSE OUTPUT on the general purpose oscilloscope with the output terminated in 50 ohms (2 watts) at the oscilloscope, and synchronize the oscilloscope from the SYNC OUTPUT also terminated in 50 ohms (1/2 watt) at the oscilloscope.

d. Verify a minimum repetition rate of 4 hertz or less (pulse period ≥250 milliseconds) and check the upper limit of the 40 Hz range for overlap with the lower limit of the next range. Check the upper limit of each succeeding range for overlap with the lower limit of the next range, and verify a maximum repetition rate of 40 megahertz or more (pulse period ≤25 nanoseconds).

NOTE: The maximum repetition rate (minimum period) may be checked later when the sampling oscilloscope is connected for minimum range verification (paragraph 4.5.12).

4.5.3 Pulse Width

a. Retain the test connections of step (c) in paragraph 4.5.2 and set the instrument controls as follows:

Control	Setting
REPETITION RATE controls	400 Hz
DELAY controls	minimum
WIDTH controls	maximum
DC LEVEL MODE switch	PULSE AT GRD
RISE/FALL controls	minimum
AMPLITUDE controls	maximum
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

b. Verify a maximum pulse width of 500 microseconds or more, and check the lower limit of the 500 μs range for overlap with the upper limit of the next range. Check the lower limit of each succeeding range for overlap with the upper limit of the next range, and verify a minimum pulse width of 10 nanoseconds or less.

NOTE: The minimum pulse width should be checked later when the sampling oscilloscope is connected for minimum range verification (paragraph 4.5.12).

4.5.4 Rise/Fall Times

a. Retain the test connections of step (c) in paragraph 4.5.2 and set the instrument controls as follows:

Control	Setting
REPETITION RATE controls	400 KHz
DELAY controls	minimum
WIDTH controls	1 μs
DC LEVEL MODE switch	PULSE AT GRD
RISE/FALL controls	maximum
AMPLITUDE controls	maximum
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

b. Verify maximum rise and fall times of 500 nanoseconds or more.

c. Check the lower limit of the 50-500 NS range for overlap with the upper limit of the 2-50 NS range.

NOTE: The fastest rise and fall times must be checked later when the sampling oscilloscope is connected for minimum range verification (paragraph 4.5.12).

4.5.5 Pulse Delay

a. Simultaneously monitor the PULSE OUTPUT and the SYNC OUTPUT on the general purpose oscilloscope by means of the dual trace vertical amplifier with both outputs terminated in 50 ohms at the oscilloscope, and synchronize the oscilloscope internally from the SYNC OUTPUT.

b. Set the instrument controls as follows:

Control	Setting
REPETITION RATE selector	40 Hz
REPETITION RATE vernier	fully counterclockwise
DELAY controls	maximum
WIDTH controls	maximum
DC LEVEL MODE switch	PULSE AT GRD
RISE/FALL controls	minimum
AMPLITUDE controls	maximum
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

c. Verify a maximum pulse delay of at least 50 milliseconds, and check the lower limit of the 50 MS range and each succeeding range for overlap with the upper limit of the next range. Verify that the main PULSE OUTPUT occurs approximately 15 nanoseconds before the SYNC OUTPUT when the DELAY controls are in their minimum position.

d. Turn the PULSE MODE switch to DOUBLE and verify that the minimum pulse delay is approximately 20 nanoseconds (from the leading edge of the first pulse to the leading edge of the second pulse).

NOTE: The minimum double pulse delay may be checked later when the sampling oscilloscope is connected for minimum range verification (paragraph 4.5.12).

4.5.6 Sync Output

a. Use the general purpose oscilloscope to monitor the SYNC OUTPUT terminated in 50 ohms (1/2 watt) at the oscilloscope, and synchronize the oscilloscope (internally) from the SYNC OUTPUT.

b. Set the instrument controls as follows:

Control	Setting
REPETITION RATE selector	4-40 MHz
4-40 MHz vernier	fully counterclockwise
Remaining controls	any position

c. Sweep the 4-40 MHz vernier from its fully counterclockwise position to its fully clockwise position and verify that the amplitude

of the SYNC OUTPUT remains greater than 2 volts over the entire range.

4.5.7 Duty Cycle

a. Monitor the PULSE OUTPUT on the general purpose oscilloscope with the output terminated in 50 ohms (2 watts) at the oscilloscope, and synchronize the oscilloscope from the SYNC OUTPUT also terminated in 50 ohms (1/2 watt) at the oscilloscope.

b. Set the instrument controls as follows:

Control	Setting
REPETITION RATE controls	200 KHz
DELAY selector	5 μs
DELAY vernier	fully counterclockwise
WIDTH controls	500 NS
DC LEVEL MODE switch	PULSE AT GRD
RISE/FALL controls	minimum
AMPLITUDE controls	maximum
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

c. Set the oscilloscope sweep speed to 0.5μs/cm and adjust the vertical sensitivity and time position controls for a convenient display with a single pulse at the far left of the trace.

d. Slowly turn the DELAY vernier clockwise and verify that a 75% duty cycle (3.75 microsecond delay) is attainable without waveform deterioration.

e. Set the DELAY controls to minimum, turn the WIDTH selector to 5μs with the vernier fully counterclockwise, and adjust the oscilloscope controls as for step (c).

f. Slowly turn the WIDTH vernier clockwise and verify that an 85% duty cycle (4.25 microsecond pulse width) is attainable without waveform deterioration.

4.5.8 Pulse Amplitude and Baseline Offset

a. Retain the test connections of step (a) in paragraph 4.5.7 and set the instrument controls as follows:

Control	Setting
REPETITION RATE controls	40 KHz
DELAY controls	minimum
WIDTH controls	5 μs
DC LEVEL MODE switch	PULSE AT GRD
RISE/FALL controls	minimum
AMPLITUDE controls	maximum
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

b. Adjust the oscilloscope controls for a convenient display with a single pulse on the trace. Turn the AMPLITUDE controls through their entire range and verify that the amplitude goes down smoothly from 5 volts to less than 150 millivolts without any appreciable effect on waveshape. Also check the upper limit of each range for the front panel indication (±5%).

NOTE: Vernier control must be limited to one range step as pulse distortion occurs when too much vernier attenuation is used.

c. Turn the PULSE POLARITY switch to (+) and repeat step (b).

d. Turn the DC LEVEL MODE switch to PULSE OFFSET and verify that the pulse baseline shifts smoothly from +5 to -5 volts without any appreciable effect on waveshape as the DC LEVEL vernier is turned through its range for both the (+) and (-) positions of the DC LEVEL POLARITY switch.

e. Return the PULSE POLARITY switch to (-) and repeat step (d).

4.5.9 External Trigger and Gate Control

a. Set the instrument controls as follows:

Control	Setting
REPETITION RATE controls	4 MHz
DELAY controls	minimum
WIDTH controls	50 NS
DC LEVEL MODE switch	PULSE AT GRD
RISE/FALL controls	minimum
AMPLITUDE controls	maximum
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

b. Monitor the PULSE OUTPUT on the general purpose oscilloscope with the output terminated in 50 ohms at the oscilloscope. Synchonize the oscilloscope to (-) internal and set the controls for a convenient display with 20 pulses on the trace (0.5μs/cm sweep speed).

c. Use a 50 ohm coaxial cable to connect the DISABLING GATE INPUT to the square-wave (or pulse) generator with its positive output set for a 1 microsecond pulse at an amplitude of 4 volts and a repetition rate of 400 kilohertz. Simultaneously trigger the oscilloscope externally from the gating signal terminated in 50 ohms at the oscilloscope by means of a 50 ohm cable, a BNC Tee connector, and a 1/2 watt, 50 ohm termination.

d. Verify that the PULSE OUTPUT occurs only between gate pulses.

NOTE: The output will appear unstable because the instrument is asynchronously gated and the oscilloscope is synchronized to the gate signal. To get clearly defined bursts of pulses, it is necessary to synchronize both the oscilloscope and the gate pulse generator from the instrument under test.

e. Disconnect the gate signal generator and connect the positive output of the trigger (or pulse) generator to the EXT TRIGGER INPUT with the external trigger set for an amplitude of 2 volts, a duration of 10 (or more) nanoseconds, and a repetition rate of 4 megahertz.

f. Set the R_{IN} switch to 50 Ω or 500 Ω as required, turn the REPETITION RATE selector to (+) EXT TRIG, and verify that the instrument can be slaved to the external source at frequencies ranging from 10 hertz to 40 megahertz.

g. Connect the EXT TRIGGER INPUT to the negative output of the trigger generator, switch the REPETITION RATE selector to (-) EXT TRIG, and again verify that the instrument can be slaved to the external trigger up to 40 megahertz.

4.5.10 Single Cycle Operation

a. Use the test connections of step (a) in paragraph 4.5.7 and set the instrument controls as follows:

Control	Setting
REPETITION RATE controls	400 KHz
DELAY controls	minimum
WIDTH controls	maximum

Control	Setting
DC LEVEL MODE switch	PULSE AT GRD
RISE/FALL controls	minimum
AMPLITUDE controls	maximum
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

b. Adjust the oscilloscope controls for a convenient display with a single pulse on the trace.

c. Turn the REPETITION RATE selector to SINGLE CYCLE and press the SINGLE CYCLE pushbutton. Verify that one pulse (only) occurs each time the pushbutton is actuated (and that the TRIGGERED lamp lights momentarily).

4.5.11 Jitter (Period, Width, and Delay)

a. Monitor the PULSE OUTPUT on the delayed sweep oscilloscope with the output terminated in 50 ohms at the oscilloscope, and set the instrument controls as follows:

Control	Setting
REPETITION RATE controls	100 KHz
DELAY controls	minimum
WIDTH controls	500 NS
DC LEVEL MODE switch	PULSE AT GRD
RISE/FALL controls	minimum
AMPLITUDE controls	maximum
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

b. Trigger the oscilloscope internally on the leading edge of the pulse, and set the main sweep to 1μs/cm and the delayed sweep to 0.1μs/cm.

c. Intensify the main sweep by the delayed sweep to include the leading edge of the second pulse, magnify the sweep 10:1, and select the delayed sweep for the horizontal display. Measure the period jitter at the leading edge of the second pulse and verify that it is less than 0.05% of the period (5 nanoseconds).

d. Set the REPETITION RATE to 50 KHz and the pulse WIDTH to 10μs. Intensify the trailing edge of the pulse, magnify the sweep 10:1, and select the delayed sweep for the horizontal display.

Measure the pulse width jitter (of the trailing edge) and verify that it is less than 0.05% (5 nanseconds).

e. Retain the control settings of step (d) except trigger the oscilloscope externally from the SYNC OUTPUT (terminated in 50 ohms at the oscilloscope). Set the pulse DELAY to 10μs, and intensify the leading edge of the pulse. Magnify the sweep 10:1 and select the delayed sweep for the horizontal display. Measure the delay jitter (of the leading edge) and verify that it is less than 0.05% (5 nanoseconds).

4.5.12 Minimum Period, Delay, Width, and Transition Ranges

a. Set the instrument controls as follows:

Control	Setting
REPETITION RATE controls	maximum
DELAY controls	minimum
WIDTH controls	minimum
DC LEVEL MODE switch	PULSE AT GRD
RISE/FALL controls	minimum
AMPLITUDE controls	maximum
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

b. Monitor the PULSE OUTPUT on the sampling oscilloscope using the 10:1 (1 watt minimum) attenuator, and synchronize the oscilloscope from the SYNC OUTPUT using the 1/2 watt attenuator (the 50 ohm terminations are not required).

NOTE: If a high impedance probe is used for an output, the attenuator is not required but the 50 ohm termination must be retained.

c. Verify a minimum pulse period of 25 nanoseconds or less.

d. Verify a minimum pulse width of 10 nanoseconds or less.

e. Verify a minimum rise time of less than 2 nanoseconds and a minimum fall time of less than 3 nanoseconds.

f. Reduce the repetition rate to 10 megahertz, turn the PULSE MODE switch to DOUBLE, and verify a minimum pulse delay of approximately 20 nanoseconds.

4.5.13 Output Waveform

a. Retain the test connections of step (b) in paragraph 4.5.12 and set the instrument controls as follows:

Control	Setting
REPETITION RATE controls	400 KHz
DELAY controls	minimum
WIDTH controls	500 NS
DC LEVEL MODE switch	PULSE AT GRD
RISE/FALL controls	minimum
AMPLITUDE controls	maximum
PULSE POLARITY switch	(-)
PULSE MODE switch	SINGLE
Remaining controls	any position

b. Adjust the oscilloscope controls for a convenient display, and verify that the pulse amplitude is 5 ±0.25 volts (±5%) and that pulse abberation (overshoot, undershoot, and ringing) are less than ±0.15 volts (±3%).

c. Turn the REPETITION RATE controls to 400 Hz and the WIDTH controls to maximum. Verify that top slope (pulse top droop or sag) is less than 3%.

d. Turn the PULSE POLARITY switch to (+) and repeat steps (b) and (c).

SECTION V

PARTS LIST

5.1 Abbreviations and Symbols

5.1.1 Reference Designations

Reference designations used correspond with reference designations in the following schematics:

Drawing No. D40000-155
Drawing No. D40000-156
Drawing No. J40000-170
Drawing No. J40000-171
Drawing No. J40000-172

Resistors are designated as R1, R2, R3, etc., and are in ohms, fixed value, composition, 5%, and 1/4 watt unless otherwise noted.

Capacitors are designated as C1, C2, C3, etc., and are in picofarads, fixed value, 5% (except electrolytics), and 500 volts dc unless otherwise noted.

Transistors are designated as Q1, Q2, Q3, etc., and are silicon unless otherwise noted; diodes are designated as CR1, CR2, CR3; switches as S1, S2, S3; inductors as L1, L2, L3; delay lines as DL1, DL2, DL3; transformers as T1, T2, T3, etc.

5.1.2 Abbreviations

ampere	A
alternating current	ac
ceramic	Cer.
clockwise	CW
coefficient	Coef.
concentric	Conc.
counterclockwise	CCW
dipped mica	DM
direct current	dc
double-pole-double-throw	DPDT
electrolytic	Elect.
germanium	Ge.
kilohm	k
logarithmic	Log.
manufacturer	MFR.
megohm	M
metallized	Met.

microfarad	μF
microhenry	μH
milliampere	mA
milliwatt	mW
modified	Mod.
nanosecond	ns
negative-positive-negative	NPN
number	NO.
picofarad	pF
position	Pos.
positive-negative-positive	PNP
potentiometer	Pot.
quantity	QTY.
reference	REF.
section	Sec.
silicon	Si.
silvered mica	SM
single-pole-double-throw	SPDT
special	Spec.
tantalum	Ta.
temperature	Temp.
transformer	xfmr.
variable	Var.
volts	V
watts	W
wire wound	WW

5.1.3 Manufacturers

ACDC Electronics Incorporated	ACDC
Allen Bradley Company	AB
Alco Electronic Products, Inc.	Alco
Astrodyne Incorporated	Astrodyne
Bourns Laboratories, Incorporated	Bourns
Bussman Manufacturing Company	Buss
Centralab	CRL
Chicago Telephone Supply	CTS
Continental-Wirt	C-W
Cornell Dubilier Electronics	CD
Corning Glass Works	Corning
Datapulse Inc.	DP
Dialight Corporation	Dialco
Diodes Incorporated	DI
Drake Manufacturing Company	Drake
Elco Corporation	Elco
Electro Cube Incorporated	EC
Electro Motive Manufacturing Company	Elmenco
Erie Technological Products Incorporated	Erie
Fairchild Semiconductor Products Incorporated	FT

Ferroxcube Corporation of America	FC
General Electric Company	GE
Goodall Division of TRW Electronics Inc.	Goodall
Grayhill Incorporated	Grayhill
Hewlett-Packard Company	HPA
IMB Electronic Products	IMB
International Electronics Corporation	IEC
International Resistance Company, Inc.	IRC
Littelfuse Incorporated	Littelfuse
Magnetic Components Incorporated	MCI
Mallory, P. R., and Company	Mallory
McCarron Transformer Company	McCarron
Miller, J. W., and Company	Miller
Mitsumi Electric	Mitsumi
Motorola Semiconductor Products Incorporated	Mot.
Ny-Glass, Inc.	Ny-Glass
Nytronics Incorporated	Nytronics
Oak Manufacturing Company	Oak
Ohmite Manufacturing Company	Ohmite
Radio Corporation of America	RCA
Radio Materials Company	RMC
Sangamo Electric Company	Sangamo
Semcor Division of Components Incorporated	Semcor
Sprague Electric Company	Sprague
Stanwyck Winding Company, Inc.	Stanwyck
Switchcraft Incorporated	Sw.
Sylvania Electric Products Incorporated	Syl.
Technitrol Incorporated, Components Division	Tech.
Whale Electronics Incorporated	Whale
Wakefield Engineering Incorporated	WE
Ward Leonard Electric Company	WL
Wilco Corporation	Wilco

NOTE: Manufacturers and manufacturers' part numbers are listed to facilitate field maintenance but are subject to change without notice. When differences exist between the listed part and the part in the instrument, the listed part may be considered a suitable replacement if it has the same electrical and/or mechanical characteristics. If a design change has been made, the characteristics of the new part will be listed in the Addenda and Errata section, at the back of the manual.

5.2 · Repetition Rate Switch Assembly

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.2.1		Resistors			
R4	1	Var., 150k, 2W, 10% CCW Mod. Log.	20049-154	AB	JA1N056S154BA
R6	1	10	10010-100	AB	CB 1005
5.2.2		Capacitors			
C5	1	Var., Dual, 5-335	11292-321	Mitsumi	PVC-2K
C6	1	Ta., 33μF, 10V, 10%	11510-336	Sprague	150D336X9010B2
C7	1	Ta., 3.3μF, 10V, 10%	11510-335	Sprague	150D335X9010A2
C8	1	Met. Mylar, 0.33μF, 200V, 2%	11124-334	EC	210B1C334G
C9	1	Met. Mylar, .033μF, 200V, 2%	11124-333	EC	210B1C333G
C10	1	SM, 2700, 2%	11047-272	Sangamo	CR5E272G
C11	1	SM, 150	11017-151	Sangamo	RR1315
5.2.3		Switches			
S1	1	Rotary, 10 Pos., 5 Sec., 30° Throw, Shorting, 5 Pole	25250-032	Oak	245179-N5

5.3 Delay Switch Assembly

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.3.1		Resistors			
R116	1	Var., 100k, 2W, 10% CW Mod. Log.	20043-104	AB	JA1N56S104AA
5.3.2		Capacitors			
C112	1	SM, 91	11017-910	Sangamo	CM15C910J03
C113	1	SM, 1000, 1%	11027-102	Elmenco	CM20E102F
C114	1	SM, .01μF, 300V, 1%	11025-103	Elmenco	CM35E103F
C115	1	Met. Mylar, 0.1μF, 200V, 1%	11124-104	EC	210B1C104F
C116	1	Met. Mylar, 1μF, 200V, 1%	11124-105	EC	210B1C105F
C117	1	Ta., 10μF, 20V, 10%	11511-106	Sprague	150D106X9020B2
5.3.3		Switches			
S101	1	Rotary, 7 Pos., 2 Sec., 45° Throw, Shorting	25250-031	Oak	245136-AF2

5.4 Width Switch Assembly

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.4.1		Resistors			
R154	1	Var., 100k, 2W, 10%, CW Mod. Log.	20043-104	AB	JA1N056S104AA
5.4.2		Capacitors			
C147	1	SM, 91	11017-910	Sangamo	CM15C910J03
C148	1	SM, 1000, 1%	11027-102	Elmenco	CM20E102F
C149	1	SM, .01μF, 300V, 1%	11025-103	Elmenco	CM35E103F
C150	1	Met. Mylar, 0.1μF, 200V, 1%	11124-104	EC	210B1C104F
5.4.3		Switches			
S141	1	Rotary, 6 Pos., 2 Sec., 45° Throw, Shorting	25250-033	Oak	245021-AF2

5.5 Attenuator Assembly

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.5.1		Resistors			
R327	1	1k	10010-102	AB	CB1025
R332	1	470	10010-471	AB	CB4715
R337	2	2.7k	10010-272	AB	CB2725
R369		Same as R337			
R450	1	Var., 1k, 2W, 10%, Linear	20053-102	AB	JA1N056S102UA
R472	2	24, 2W	10013-240	AB	HB2405
R473	1	36, 2W	10013-360	AB	HB3605
R474		Same as R472			
R475	2	27, 2W	10013-270	AB	HB2705
R476	1	33, 2W	10013-330	AB	HB3305
R477		Same as R475			
R478	2	10M	10010-106	AB	CB1105
R479		Same as R478			
R481	1	3.3k	10010-332	AB	CB3325
R482	1	10k	10010-103	AB	CB1035
5.5.2		Capacitors			
C457	2	Cer. Disc, .022μF, 25V, +80%, -20%, HY-525	11241-223	Sprague	CO69B250G223Z
C458		Same as C457			
C459	1	Cer. Disc, 0.47μF, 10V, +80%, -20%	11240-474	CRL	UK10-474
5.5.3		Diodes			
CR452	4	Si. Signal, DP16-0, IN3600	22164-000	FT	FD6282
CR453		Same as CR452			
CR454		Same as CR452			
CR455		Same as CR452			
5.5.4		Miscellaneous			
L451	1	Inductor, 3.6μH, 850	14244-000	FC	VK-20020/4B
L452	1	Inductor, 1mH, 15, 5%	14254-102	Stanwyck	410000
T450	1	Balun, Ferrite Core	19150-008	FC	846T2503E2A
S453	1	Switch, Rotary, 3 Pos., 1 Sec., 60° Throw, Non-Shorting	25260-006	Oak	256747-K1

5.6 Front Panel Assembly

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.6.1		Resistors			
R42	1	Var., 1k, 2W, 10% Linear	20053-102	AB	JA1N056S102UA
R328	1	Var., 25k, Dual, 2W, 10%, Linear	20113-253	AB	JD1N056S253UA
R331	1	Var., 25k, Dual, 2W, 10%, CW Mod. Log.	20119-253	AB	JD1N056S253AA
R336	2	200k, 1/2W	10011-204	AB	EB2045
R345		Same as R336			
R365	1	680	10010-681	AB	CB6815
R450	1	Var., WW, 1k, 1.5W, 3%, 5 Turn	10543-102	Bourns	3520S-1-102
R471	1	910	10010-911	AB	CB9115
5.6.2		Capacitors			
C19	1	Cer. Disc, 0.1μF, +80%, -20%, 75V	11242-104	CRL	DDA-104
C460	1	Cer., 1.5±.25, Tubular	11268-155	Erie	CC20-CK-1R5C
5.6.3		Diodes			
CR450	2	Si., Signal, DP16-0, 1N3600	22164-000	FT	FD6282
CR451		Same as CR450			
5.6.4		Switches			
S2	1	Pushbutton, SPDT, 30W, Red	15300-001	Sw.	903-1C-Red
S41	2	Toggle, SPDT, 5A, 115V ac	15280-001	Alco	MST-115D
S61	1	Toggle, DPDT, 5A, 115V ac	15280-002	Alco	MST-215N
S450	1	Toggle, 3PDT, 3A, 115V ac	15280-016	Alco	MST-305E
S451	1	Toggle, 4PDT, 3A, 115V ac	15280-017	Alco	MST-405N
S452	1	Toggle, 3PDT, 3A, 115V ac	15280-015	Alco	MST-305D
S501		Same as S41			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.6.5		Miscellaneous			
DS60	1	Lamp, Cartridge, Red, 6V, 50mA	15450-034	Dialco	39-640-1471
DS61	1	Lamp, Cartridge, Green, 28V, 40mA	15450-035	Dialco	39-28-1472

5.7 Back Panel Assembly

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.7.1		Transistors			
Q504	4	NPN, Power	12675-007	RCA	38880
Q514		Same as Q504			
Q604		Same as Q504			
Q614		Same as Q504			
5.7.2		Switches			
S502	1	Slide, DPDT, 3A, 115V ac	15310-003	C-W	G326 Mod.
5.7.3		Miscellaneous			
F501	1	Fuse, 3A, Fast blow	15470-003	Buss	AGC-3
	1	Heat Sink	15550-122	Astrodyne	2505
T501	1	Xfmr., Power	24010-005	McCarron	17900
T601	1	Xfmr., Power	24010-012	ACDC	28970

5.8 Front End Circuit Board Assembly

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.8.1	Resistors				
R1	1	100k	10010-104	AB	CB1045
R2	1	Var., 250k, 0.2W, 30%, Linear	20240-254	CTS	Series UPM-70
R3	1	Var., 10k, 0.2W, 30%, Linear	20240-103	CTS	Series UPM-70
R5	3	1.2k	10010-122	AB	CB1225
R7	1	1k	10010-102	AB	CB1025
R8	1	6.8k	10010-682	AB	CB6825
R9	5	270	10010-271	AB	CB2715
R10	2	2.7k	10010-272	AB	CB2725
R11	4	330	10010-331	AB	CB3315
R12	16	47	10010-470	AB	CB4705
R13	5	39k	10010-392	AB	CB3925
R14		Same as R13			
R15		Same as R13			
R16	3	10k	10010-103	AB	CB1035
R17		Same as R16			
R18		Same as R12			
R19		Same as R13			
R20	4	12k	10010-123	AB	CB1235
R21		Same as R20			
R22	1	1.5k	10010-152	AB	CB1525
R23	1	8.2k	10010-822	AB	CB8225
R24	3	150	10010-151	AB	CB1515
R25	1	1.5k, 1W	10012-152	AB	GB1525
R26	2	820	10010-821	AB	CB8215
R27	5	4.7k	10010-472	AB	CB4725
R28	2	180	10010-181	AB	CB1815
R29	2	2.2k	10010-222	AB	CB2225
R30		Same as R5			
R31		Same as R5			
R41	1	51, 1W	10012-510	AB	GB5105
R43	1	2.7k, 1W, 10%	10022-272	AB	GB2721
R44		Same as R12			
R45	5	1.8k, 1/2W	10011-182	AB	EB1825
R46		Same as R29			
R47		Same as R12			
R48	5	1.2k, 1W	10012-122	AB	GB1225
R49		Same as R24			
R50		Same as R12			
R51		Same as R16			
R52		Same as R20			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
R61	1	100	10010-101	AB	CB1015
R62	4	1.5k, 1/2W	10011-152	AB	EB1525
R63	1	68	10010-680	AB	CB6805
R64	3	51	10010-510	AB	CB5105
R65		Same as R27			
R66		Same as R11			
R67		Same as R48			
R68	1	1.8k	10010-182	AB	CB1825
R69		Same as R9			
R70		Same as R9			
R71	2	22	10010-220	AB	CB2205
R72	1	3.3k	10010-332	AB	CB3325
R73		Same as R11			
R74	1	680, 1/2W	10011-681	AB	EB6815
R75		Same as R27			
R81		Same as R13			
R82		Same as R12			
R83	2	220	10010-221	AB	CB2215
R84	1	2k, 1/2W	10011-202	AB	CB2025
R85		Same as R12			
R86		Same as R20			
R87		Same as R10			
R88		Same as R9			
R89		Same as R9			
R90	1	10	10010-100	AB	CB1005
R91	5	820, 1W, 10%	10022-821	AB	GB8211
R92		Same as R26			
R101		Same as R62			
R102		Same as R27			
R103		Same as R62			
R104		Same as R12			
R105	2	3.3k, 1/2W	10010-332	AB	EB3325
R106		Same as R91			
R107		Same as R83			
R108		Same as R62			
R109		Same as R24			
R110		Same as R48			
R111	2	33k	10010-333	AB	CB3335
R112	2	Var., 500k, 0.2W, 30%, Linear	20240-504	CTS	Series UPM-70
R113		Same as R12			
R114		Same as R45			
R115	2	Var., 5k, 0.2W, 30%, Linear	20240-502	CTS	Series UPM-70
R117	2	560	10010-561	AB	CB5615
R118	2	82	10010-820	AB	CB8205
R119		Same as R117			
R120		Same as R118			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
R121		Same as R64			
R122		Same as R64			
R123		Same as R11			
R124		Same as R12			
R125		Same as R12			
R126		Same as R45			
R127		Same as R45			
R128		Same as R91			
R141		Same as R91			
R142		Same as R48			
R143		Same as R27			
R144		Same as R12			
R145		Same as R105			
R146		Same as R28			
R147		Same as R71			
R148		Same as R91			
R149		Same as R111			
R150		Same as R112			
R151		Same as R12			
R152		Same as R45			
R153		Same as R115			
R155		Same as R12			
R156		Same as R12			
R157		Same as R12			
R158	1	2.7k, 1/2W	10011-272	AB	EB2725
R159		Same as R48			
5.8.2		Capacitors			
C1	3	Cer. Disc., 0.1μF, 75V, +80%, -20%	11242-104	CRL	DDA-104
C2	7	Elect., 100μF, 35V	11162-107	Whale	20-500BP100-35S85
C3	13	Elect., 05μF, 25V	11241-503	RMC	MAGNACAP
C4	2	Var., Cer., 7-25, 350V, Temp. Coef. N300	11305-250	Erie	0538-014-93R
C12		Same as C3			
C13	5	SM, 47	11017-470	Sangamo	DR5E470J
C14		Same as C13			
C15		Same as C3			
C16	3	SM, 27	11017-270	Sangamo	RR5E270J
C17	2	Elect., 1μF, 50V, +100%, -0%	11159-105	Whale	11-215BP1-50D65
C18		Same as C17			
C41		Same as C13			
C42	3	Elect., 100μF, 15V	11169-107	Whale	12-437B100-15S65
C44		Same as C3			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
C45		Same as C2			
C46		Same as C2			
C47		Same as C3			
C48		Same as C2			
C50	2	SM, 100	10017-101	Sangamo	RR1310
C61		Same as C3			
C62		Same as C13			
C63		Same as C3			
C64	1	Ta., 4.7μF, 20V, 20%	11491-475	Sprague	196D475X0020-EB
C81		Same as C16			
C82		Same as C3			
C83		Same as C16			
C84		Same as C50			
C85		Same as C3			
C101		Same as C42			
C102	1	33, SM	11017-330	Elmenco	CM15E330J
C103		Same as C3			
C104	2	DM, 1000, 100V	11073-102	Elmenco	DM15-102J
C105		Same as C2			
C106		Same as C1			
C107		Same as C4			
C108	1	DM, 82	11077-820	Elmenco	DM15-820J
C109	1	DM, 68	11077-680	Elmenco	DM15-680J
C110		Same as C42			
C111	2	Var., Cer., 7-45, Temp. Coef. N500	11307-450	Erie	503-000-33C
C118	2	SM, 68	11017-680	Sangamo	RR1468
C119		Same as C118			
C120		Same as C3			
C141		Same as C13			
C142		Same as C3			
C143		Same as C104			
C144	1	DM, 22	11077-220	Elmenco	DM15-220J
C145		Same as C1			
C146		Same as C111			
C151		Same as C3			
C455		Same as C2			
C456		Same as C2			
5.8.3	Transistors				
Q1	2	PNP	12605-005	FT	2N3638
Q2	18	NPN, DP63-3, 2N2369A	22635-003	FT	S15171
Q3		Same as Q2			
Q4		Same as Q2			
Q5	6	PNP, DP60-6	22605-006	FT	2N3640

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
Q6		Same as Q5			
Q7		Same as Q2			
Q8		Same as Q2			
Q9		Same as Q2			
Q10		Same as Q2			
Q11		Same as Q2			
Q12		Same as Q5			
Q13		Same as Q2			
Q14		Same as Q2			
Q15		Same as Q1			
Q16	1	NPN	12635-998	FT	2N3641
Q17		Same as Q2			
Q18		Same as Q2			
Q19		Same as Q2			
Q20		Same as Q2			
Q21		Same as Q2			
Q22	2	NPN	12645-006	RCA	2N3261
Q23		Same as Q22			
Q24		Same as Q5			
Q25		Same as Q5			
Q26		Same as Q2			
Q27		Same as Q2			
Q28		Same as Q2			
Q29		Same as Q5			
5.8.4	Diodes				
CR1	20	Si., Signal, DP16-0, 1N3600	22164-000	FT	FD6282
CR2	1	Si., Signal	12224-001	HPA	5082-2900
CR3	14	Ge., Signal	12144-003	Syl.	1N995
CR4		Same as CR3			
CR5		Same as CR3			
CR6		Same as CR3			
CR7		Same as CR3			
CR41		Same as CR1			
CR42		Same as CR3			
CR43		Same as CR3			
CR44		Same as CR3			
CR45		Same as CR3			
CR46		Same as CR3			
CR47		Same as CR3			
CR48		Same as CR3			
CR61		Same as CR1			
CR62		Same as CR3			
CR63		Same as CR1			
CR64		Same as CR1			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
CR81		Same as CR1			
CR82		Same as CR3			
CR83		Same as CR1			
CR84		Same as CR1			
CR85		Same as CR1			
CR86		Same as CR1			
CR87		Same as CR1			
CR101		Same as CR1			
CR102		Same as CR1			
CR103		Same as CR1			
CR104	3	Ge., Tunnel Diode	12254-001	GE	1N3717
CR105		Same as CR104			
CR106		Same as CR1			
CR107		Same as CR1			
CR141		Same as CR1			
CR142		Same as CR1			
CR143		Same as CR1			
CR144		Same as CR104			
CR145		Same as CR1			
5.8.5		Miscellaneous			
L1	1	Inductor, 1.5μH, Phenolic Core	14284-005	Wilco	207-11-15
L2	1	Inductor, 1μH, Phenolic Core	14284-002	Wilco	205-11-10
L41	3	RF Choke, 0.68μH	14264-000	Nytron-ics	SWD0.68
L81		Same as L41			
L101		Same as L41			
DL61	1	Delay Line, 70ns, ±5%, 50Ω, ±10%	14225-087	Tech.	500H700A
--	12	Bead	19170-000	DP	19170-000
--	2	Heat Sink	15550-111	WE	NF203

5.9 Output Amplifier Circuit Board Assembly

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.9.1	Resistors				
R201	6	22	10010-220	AB	CB2205
R202	2	1.5k, 1W	10012-152	AB	GB1525
R203	1	Var., 1k, 1/2W, 10%	10439-102	AB	SV1021
R204	1	820, 1W	10012-821	AB	GB8215
R205	1	68	10010-680	AB	CB6805
R206	1	750, 1W	10012-751	AB	GB7515
R207	2	1.2k, 1W	10012-122	AB	GB1225
R208	1	220	10010-221	AB	CB2215
R209	3	3.3k, 1/2W	10011-332	AB	EB3325
R210	7	10k	10010-103	AB	CB1035
R300		Same as R201			
R301	1	1.21k, 1/2W, 1% Metal Film, 350V	10712-132	IRC	RN70C1211F
R302	1	1k, 1/2W, 1%, Metal Film, 350V	10712-102	IRC	RN70C1001F
R303	4	33	10010-330	AB	CB3305
R305	1	750	10010-751	AB	CB7515
R309		Same as R201			
R313	1	5.6k	10010-562	AB	CB5625
R314	1	180	10010-181	AB	CB1815
R315	3	100	10010-101	AB	CB1015
R316	1	330	10010-331	AB	CB3315
R317	1	1.5k	10010-152	AB	CB1525
R318	5	4.7k	10010-472	AB	CB4725
R319	4	1k	10010-102	AB	CB1025
R320		Same as R319			
R321		Same as R318			
R322	2	150	10010-151	AB	CB1515
R323	1	1.2k	10010-122	AB	CB1225
R324		Same as R210			
R325	4	10	10010-100	AB	CB1005
R326		Same as R325			
R329		Same as R207			
R330	1	1.8k, 1/2W	10011-182	AB	EB1825
R333		Same as R315			
R334	3	2.7	10010-279	AB	CB27G5
R335		Same as R202			
R338	3	15k	10010-153	AB	CB1535
R339	1	82	10010-820	AB	CB8205
R340		Same as R318			
R341		Same as R210			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
R343	1	2.2k, 1/2W	10011-222	AB	EB2225
R344	2	82k	10010-823	AB	CB8235
R350		Same as R303			
R351		Same as R315			
R353	1	2k	10010-202	AB	CB2025
R354	2	Var., 1k, 0.2W, 30% Linear	20240-102	CTS	Series UPM-70
R355	1	1.5k, 1/2W	10011-152	AB	EB1525
R356	4	47	10010-470	AB	CB4705
R357	1	470	10010-471	AB	CB4715
R358		Same as R354			
R359	1	3.9k	10010-392	AB	CB3925
R360		Same as R210			
R361	2	22.1k, 1/8W, 1% Metal Film	10690-223	IRC	RN60C2212F
R362	1	33k	10010-333	AB	CB3335
R363		Same as R325			
R366		Same as R325			
R367	2	Var., 10k, 0.2W, 80% Linear	20240-103	CTS	Series UPM-70
R368		Same as R338			
R370	1	1k, 1W	10012-102	AB	GB1025
R371	1	27k	10010-273	AB	CB2735
R372	1	WW, 50, 5W	10264-501	Sprague	242E5015
R373	1	680, 1/2W	10011-681	AB	EB6815
R374		Same as R201			
R375		Same as R367			
R376		Same as R356			
R377		Same as R356			
R378	2	1M	10010-105	AB	CB1055
R379		Same as R201			
R380		Same as R210			
R381	4	2.7k	10010-272	AB	CB2725
R382		Same as R209			
R383		Same as R209			
R384		Same as R201			
R385		Same as R303			
R386		Same as R303			
R387		Same as R334			
R388		Same as R334			
R389	1	470	10010-471	AB	CB4715
R390		Same as R322			
R400		Same as R361			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
R401	1	200, 1/2W	10011-201	AB	EB2015
R402	3	100k	10010-104	AB	CB1045
R403	1	Var., 100k, 0.2W, 30% Linear	20240-104	CTS	Series UPM-70
R404	1	39k	10010-393	AB	CB3935
R405	1	19.6k, 1/8W, 1% Metal Film, 250V	10690-196	IRC	RN60C1962F
R406	1	150k	10010-154	AB	CB1545
R407	1	8.25k, 1/8W, 1% Metal Film, 250V	10690-825	IRC	RN60C8251F
R408		Same as R402			
R409		Same as R210			
R410	1	5.62k, 1/8W, 1% Metal Film, 250V	10690-562	IRC	RN60C5621F
R411		Same as R210			
R412		Same as R338			
R413		Same as R318			
R414	1	3.83k, 1/8W, 1% Metal Film, 250V	10690-383	IRC	RN60C3831F
R415	1	47k	10010-473		
R416		Same as R344			
R417	1	3.3k	10010-332	AB	CB3325
R418	1	6.8k	10010-682	AB	CB6825
R419		Same as R381			
R420		Same as R378			
R421	1	2.2k	10010-222	AB	CB2225
R422	1	4.7M	10010-475		
R423		Same as R319			
R424	1	22k	10010-223	AB	CB2235
R425		Same as R402			
R426		Same as R381			
R427	1	390, 2W	10013-391	AB	HB3915
R428		Same as R319			
R429		Same as R318			
R430	1	39, 2W	10013-390	AB	HB3905
R431		Same as R381			
5.9.2	Capacitors				
C201	19	Cer. Disc, .022μF, 25V +80%, -20%, HY-525	11241-223	Sprague	CO69B250G-223Z
C202		Same as C201			
C203	1	DM, 22	11077-220	Elmenco	DM15-220J
C204		Same as C201			
C205		Same as C201			
C300		Same as C201			
C302		Same as C201			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
C305	3	DM, 10	11077-100	Elmenco	DM15-100J
C306		Same as C305			
C307	1	SM, 10	10017-100	Sangamo	DR5C100J03
C308	4	DM, 47	11077-470	Elmenco	DM15-470J
C309		Same as C308			
C310		Same as C201			
C311		Same as C201			
C312	1	DM, 150	11077-151	Elmenco	DM15-151J
C313		Same as C308			
C314	1	DM, 22	11077-220	Elmenco	DM15-220J
C316		Same as C201			
C317		Same as C201			
C319	2	Cer. Feed-Thru, .001μF, 20%	11277-102	Erie	2404000X5U0 102F
C321		Same as C319			
C322	1	DM, 180	11077-181	Elmenco	DM15-181J
C323		Same as C305			
C350		Same as C201			
C351		Same as C201			
C352	1	Ta., 4.7μF, 20V, 20%	11491-475	Sprague	196D475X-0020EB
C353	1	SM, 270	11017-271	Sangamo	RR5E271J03
C354		Same as C201			
C355		Same as C308			
C356		Same as C201			
C357		Same as C201			
C358	2	DM, 5, 10%	11077-509	Elmenco	DM10-050K
C359		Same as C358			
C360		Same as C201			
C361	4	Ta., 1μF, 35V, 20%	11512-105	Sprague	150D105X-0035A2
C362		Same as C201			
C363	2	DM, 39	11077-390	Sangamo	D155E390J
C364		Same as C363			
C365		Same as C201			
C366		Same as C361			
C367		Same as C361			
C368		Same as C201			
C400	2	Elect., 100μF, 35V	11162-107	Whale	20-500BP100-35S85
C401	1	Elect., 100μF, 15V	11169-107	Whale	12-437BP100-15S65
C402		Same as C361			
C403	1	Cer. Disc, 0.1μF, 75V	11242-104	CRL	DDA-104
C404		Same as C400			
C601	2	Elect., 1000μF, 50V	11162-108	Whale	36-1000BP-1000-50S65
C631		Same as C601			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.9.3		Transistors			
Q201	4	NPN, DP63-3, 2N2369A	22635-003	FT	S15171
Q202		Same as Q201			
Q203		Same as Q201			
Q204	5	PNP, DP60-6	22605-006	FT	2N3640
Q301	1	NPN	12645-013	RCA	2N5179
Q302		Same as Q201			
Q305		Same as Q204			
Q306	6	NPN	12645-006	RCA	2N3261
Q307		Same as Q204			
Q308		Same as Q306			
Q309		Same as Q204			
Q310		Same as Q306			
Q311	3	PNP, DP60-5	22605-005	FP	FT1702
Q312		Same as Q306			
Q313	7	PNP	12605-005	FT	2N3638
Q314		Same as Q204			
Q315		Same as Q311			
Q316		Same as Q311			
Q317		Same as Q306			
Q318		Same as Q306			
Q319	5	NPN	12695-007	Sprague	TZ-82
Q320		Same as Q319			
Q321		Same as Q319			
Q322		Same as Q313			
Q323		Same as Q319			
Q324		Same as Q319			
Q325		Same as Q313			
Q326	2	NPN	12695-001	RCA	2N2270
Q327	4	NPN	12635-998	FT	2N3641
Q328	1	PNP, DP59-0, 2N1132A	22595-000	FT	S17988
Q329		Same as Q327			
Q330		Same as Q313			
Q331		Same as Q326			
Q332		Same as Q313			
Q333		Same as Q313			
Q334		Same as Q327			
Q335		Same as Q327			
Q336		Same as Q313			
5.9.4		Diodes			
CR201	2	Zener, 5.6V, 400mW, 5%	12154-015	Semcor	1N752A
CR202		Same as CR201			
CR203	19	Si., Signal, DP16-0, 1N3600	22164-000	FT	FD6282
CR204		Same as CR203			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
CR301	1	Zener, Si., 3.3V, 400mW, 5%	12154-030	Mot.	1N746A
CR304		Same as CR203			
CR305		Same as CR203			
CR306		Same as CR203			
CR307		Same as CR203			
CR308	3	Zener, Si., 15V, 1W, 5%	12154-017	Semcor	Type M4Z
CR309	3	Si., Signal	12224-001	HPA	5082-2900
CR310		Same as CR203			
CR311		Same as CR203			
CR312		Same as CR203			
CR313	3	Si., Signal	12184-005	HPA	5082-8830
CR314		Same as CR313			
CR350		Same as CR313			
CR351		Same as CR308			
CR352	1	Ge, Signal	12144-003	Syl.	1N995
CR353		Same as CR203			
CR354		Same as CR203			
CR355		Same as CR203			
CR356		Same as CR203			
CR357		Same as CR203			
CR358		Same as CR309			
CR359		Same as CR309			
CR400		Same as CR203			
CR401		Same as CR203			
CR402		Same as CR308			
CR403		Same as CR203			
CR404		Same as CR203			
CR405	1	Zener, Si., 10V, 400mW, 5%, DP31-100	12154-041	Semcor	1N758A
CR406		Same as CR203			
5.9.5	Miscellaneous				
L350	1	Inductor, 1.8μH, Phenolic Core	14284-004	Wilco	208-11-18
--	20	Bead, Ferrite	19170-000	DP	19170-000
--	6	Half Bead, Ferrite	19170-001	DP	19170-001
--	3	Heat Sink	15550-111		
--	1	Heat Sink	15550-112		
ST-301	1	Encapsulating Cup for Stub Tuner	19210-000	Ny-Glass	N-102

5.10 Grounded Power Supply Circuit Board Assembly

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.10.1		Resistors			
R501	2	2.2k	10010-222	AB	CB2225
R502	6	10k	10010-103	AB	CB1035
R503	2	1.2k, 1/2W	10011-122	AB	EB1225
R504	2	4.7k	10010-472	AB	CB4725
R505	4	1.5k	10010-152	AB	CB1525
R506		Same as R505			
R507		Same as R502			
R508	2	WW, 1, 3W	10264-109	Sprague	450E1R05
R509	2	150	10010-151	AB	CB1515
R510	2	3.6k, 1/2W	10011-362	AB	EB3625
R511	2	6.8k	10010-682	AB	CB6825
R512	4	Var., 1k, 0.2W, 30%, Linear	20240-102	CTS	Series UPM-70
R513	2	3.9k	10010-392	AB	CB3925
R514	2	12k	10010-123	AB	CB1235
R515		Same as R512			
R516	2	2.7k	10010-273	AB	CB2725
R517	2	18k	10010-183	AB	CB1835
R518	2	1.2k	10010-122	AB	CB1225
R519	2	3.3k	10010-332	AB	CB3325
R520		Same as R502			
R521	1	WW, 200, 5W	10304-201	WL	SF200WL
R522	2	4.7, 1W	10012-479	AB	GB47G5
R531		Same as R501			
R532		Same as R502			
R533		Same as R503			
R534		Same as R504			
R535		Same as R505			
R536		Same as R505			
R537		Same as R502			
R538		Same as R508			
R539		Same as R509			
R540		Same as R510			
R541		Same as R511			
R542		Same as R512			
R543		Same as R513			
R544		Same as R516			
R545		Same as R512			
R546		Same as R514			
R547		Same as R517			
R548		Same as R518			
R549		Same as R519			
R550		Same as R502			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
R551		Same as R522			
5.10.2	Capacitors				
C501	2	Elect., 1500μF, 50V	11162-158	Sangamo	505-2236-02
C502	2	Elect., 10μF, 50V	11152-100	Sprague	TE 1304
C503	6	Elect., 100μF, 35V	11162-107	Whale	20-500BP100-35S85
C504		Same as C503			
C505	2	Cer. Disc., 0.47μF, 10V, +80%, -20%	11240-474	CRL	UK10-474
C506		Same as C503			
C529	2	Cer. Disc., .05μF, 25V, +80%, -20%	11241-503	Erie	5855YU5032
C530		Same as C529			
C531		Same as C501			
C532		Same as C502			
C533		Same as C503			
C534		Same as C503			
C535		Same as C505			
C536		Same as C503			
5.10.3	Transistors				
Q501	7	NPN	12695-001	RCA	2N2270
Q502		Same as Q501			
Q503	5	PNP	12506-005	FT	2N3638
Q505		Same as Q501			
Q506	2	NPN	12635-998	FT	2N3641
Q507		Same as Q503			
Q508		Same as Q503			
Q509	3	NPN, DP63-4	22635-004	FT	2N3646 or 2N3605
Q510		Same as Q501			
Q511		Same as Q501			
Q512		Same as Q501			
Q513		Same as Q503			
Q515		Same as Q501			
Q516		Same as Q506			
Q517		Same as Q509			
Q518		Same as Q509			
Q519		Same as Q503			
Q520	1	PNP, DP59-0, 2N1132A	22595-000	FT	S17988

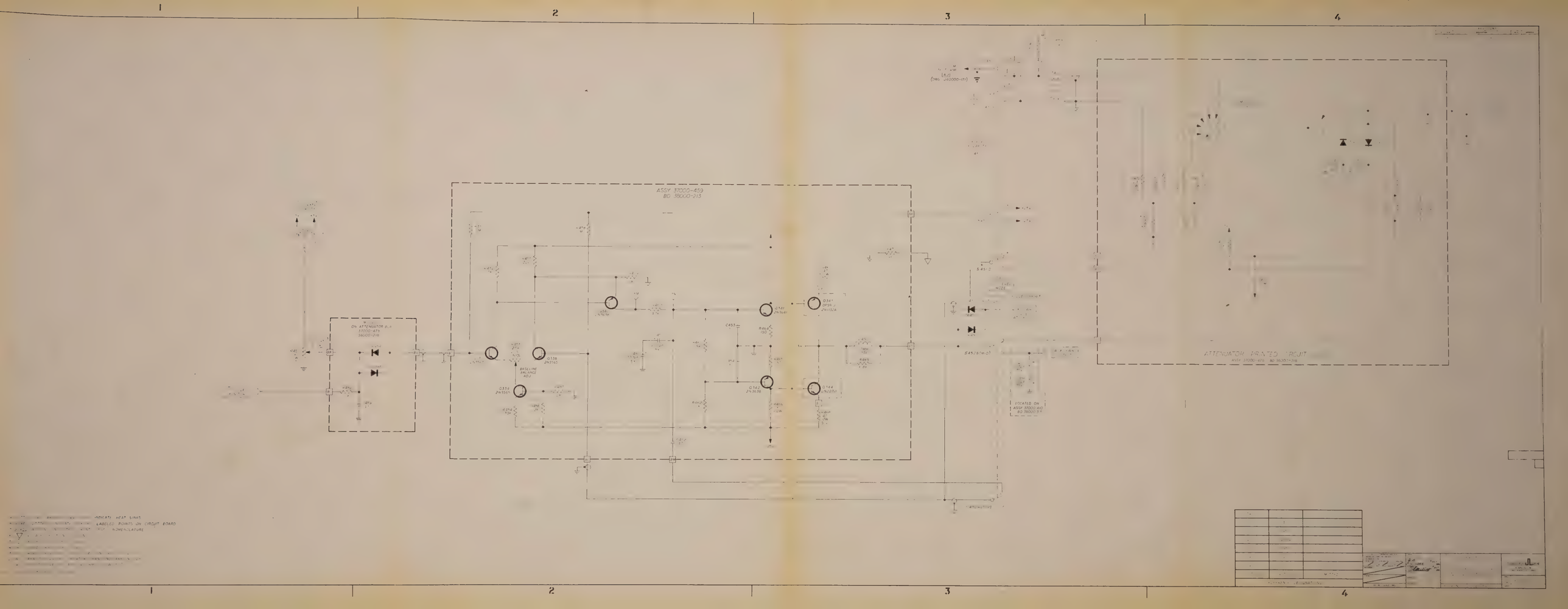
REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.10.4		Diodes			
CR501	12	Si., Rectifier, DP19-1, 1N4002	22194-001	DI	SD-1
CR502		Same as CR501			
CR503		Same as CR501			
CR504		Same as CR501			
CR505	2	Zener, 9V, 5%, 0.5W	12154-201	Mot.	1N936
CR506		Same as CR501			
CR507		Same as CR501			
CR531		Same as CR501			
CR532		Same as CR501			
CR533		Same as CR501			
CR534		Same as CR501			
CR535		Same as CR505			
CR536		Same as CR501			
CR537		Same as CR501			
5.10.5		Miscellaneous			
--	4	Heat Sink	15550-112	WE	NF209

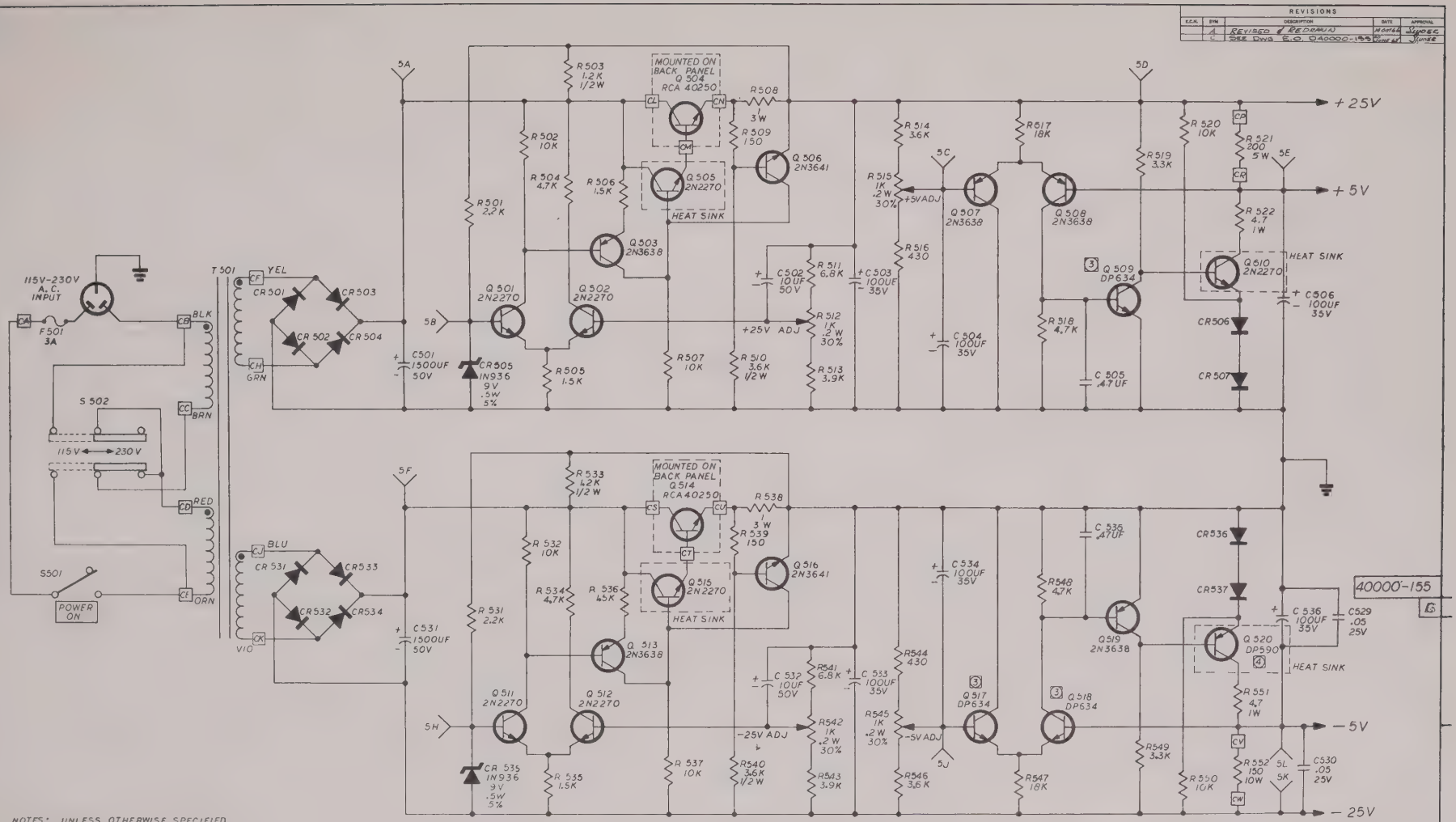
5.11 Isolated Power Supply Circuit Board Assembly

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.11.1	Resistors				
R451	2	1M	10010-105	AB	CB1055
R452	1	27k	10010-273	AB	CB2735
R453	1	Var., 2.5k, 0.2W, 30%, Linear	20240-252	CTS	Series UPM-70
R454	1	33k	10010-333	AB	CB3335
R455	1	220	10010-221	AB	CB2215
R456	2	12k	10010-123	AB	CB1235
R457		Same as R456			
R458		Same as R451			
R459	1	1k	10010-102	AB	CB1025
R460	5	4.7k	10010-472	AB	CB4725
R461	5	1.5k	10010-152	AB	CB1525
R462	1	22k	10010-223	AB	CB2235
R463	2	1k, 1/2W	10011-102	AB	EB1025
R464	4	150	10010-151	AB	CB1515
R465		Same as R464			
R466		Same as R463			
R467	2	WW, 47, 10W	10305-470	Ohmite	3770
R468		Same as R467			
R469	3	6.8k	10010-682	AB	CB6825
R470	1	910	10010-911	AB	CB9115
R552	1	WW, 150, 10W	10305-151	WL	10F150WL
R601	2	2.2k	10010-222	AB	CB2225
R602	6	10k	10010-103	AB	CB1035
R603	2	1.2k, 1/2W	10011-122	AB	EB1225
R604		Same as R460			
R605		Same as R461			
R606		Same as R461			
R607		Same as R602			
R608	2	WW, 1, 3W	10264-109	Sprague	450E1R05
R609		Same as R464			
R610	2	3.6k, 1/2W	10011-362	AB	EB3625
R611		Same as R469			
R612	4	Var., 1k, 0.2W, 30%, Linear	20240-102	CTS	Series UPM-70
R613	2	3.9k	10010-392	AB	CB3925
R614	2	3.6k	10010-362	AB	CB3625
R615		Same as R612			
R616	2	430	10010-431	AB	CB4315
R617	2	18k	10010-183	AB	CB1835
R618		Same as R460			
R619	2	3.3k	10010-332	AB	CB3325

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
R620		Same as R602			
R621	2	WW, 200, 5W	10304-201	WL	5F200WL
R622	2	4.7k, 1W	10012-479	AB	GB4795
R631		Same as R601			
R632		Same as R602			
R633		Same as R603			
R634		Same as R460			
R635		Same as R461			
R636		Same as R461			
R637		Same as R602			
R638		Same as R608			
R639		Same as R464			
R640		Same as R610			
R641		Same as R469			
R642		Same as R612			
R643		Same as R613			
R644		Same as R616			
R645		Same as R612			
R646		Same as R614			
R647		Same as R617			
R648		Same as R460			
R649		Same as R619			
R650		Same as R602			
R651		Same as R622			
R652		Same as R621			
R653	1	220k	10010-224	AB	CB2245
5.11.2	Capacitors				
C450	2	Elect., 200µF, 6V	11160-207	Whale	16-375BP200-6565
C451		Same as C450			
C452	1	Met. Mylar, 0.47µF, 250V, 20%	11134-474	IEC	CM4700-2
C453	2	Cer. Disc, .01µF, +80%, -20%	11247-103	Erie	841000-25V0-01032
C454		Same as C453			
C602	2	Elect., 10µF, 50V	11152-106	Sprague	31D165
C603	6	Elect., 100µF, 35V	11162-107	Whale	20-500BP100-35S85
C604		Same as C603			
C605	2	Cer. Disc, 0.47µF, 10V, +80%, -20%	11240-474	CRL	UK10-474
C606		Same as C603			
C632		Same as C602			
C633		Same as C603			
C634		Same as C603			
C635		Same as C605			
C636		Same as C603			

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	MFR.	MFRS. PART NO.
5.11.3		Transistors			
Q337	3	NPN	12695-007	Sprague	TZ-82
Q338		Same as Q337			
Q339		Same as Q337			
Q340	7	PNP	12605-005	FT	2N3638
Q341	3	NPN	12635-998	FT	2N3641
Q342		Same as Q340			
Q343	2	PNP, DP59-0, 2N1132A	22595-000	FT	S17988
Q344	8	NPN	12695-001	RCA	2N2270
Q601		Same as Q344			
Q602		Same as Q344			
Q603		Same as Q340			
Q605		Same as Q344			
Q606		Same as Q341			
Q607		Same as Q340			
Q608		Same as Q340			
Q609	3	NPN, DP63-4	22635-004	FT	2N3646 or 2N3605
Q610		Same as Q344			
Q611		Same as Q344			
Q612		Same as Q344			
Q613		Same as Q340			
Q615		Same as Q344			
Q616		Same as Q341			
Q617		Same as Q609			
Q618		Same as Q609			
Q619		Same as Q340			
Q620		Same as Q343			
5.11.4		Diodes			
CR601	12	Si., Rectifier, DP19-1, 1N4002	22194-001	DI	SD-1
CR602		Same as CR601			
CR603		Same as CR601			
CR604		Same as CR601			
CR605	2	Zener, 9V, 5%, 0.5W	12154-201	Mot.	1N936
CR606		Same as CR601			
CR607		Same as CR601			
CR631		Same as CR601			
CR632		Same as CR601			
CR633		Same as CR601			
CR634		Same as CR601			
CR635		Same as CR605			
CR636		Same as CR601			
CR637		Same as CR601			
5.11.5		Miscellaneous			
--	4	Heat Sink	15550-112	WE	NF209


ASSY 37000-459
BD 38000-213
ATTENUATOR PRINTED CIRCUIT
ASSY 37000-475 BD 38001-216
LOCATED ON
ASSY 37000-460
BD 38000-214
BASELINE
BALANCE
ADJ
INDICATES HEAT SINKS
LABELED POINTS ON CIRCUIT BOARD
NOMENCLATURE



NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTORS ARE IN OHMS, 1/4 W, 5%.
2. ALL DIODES ARE DP 19-1.
3. DP634 MAY BE REPLACED BY 2N3605, 2N3646, MPS 3646, ME 9021.
4. DP590 MAY BE REPLACED BY 2N1132A.

REFERENCE DESIGNATIONS		
T 501	T 501	
Q 501	Q 520	CR508-CR530
CR 501	CR 537	C507-C528
C 501	C 536	R523-R530
R 501	R 552	OMITTED
FIRST USED	LAST USED	

370.2-04?	111	1	1
NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES; TOLERANCES ON 3 PLACE DEC. ± .005, 2 PLACE DEC. ± .01, ANGLES ± 1°; MATERIAL; FINISH; DO NOT SCALE DWG.

DRAWN T. CROSBY MAY 66
CHECKED J. UDER .15 JUL 66
APPROVED 12 OCT 66
APPROVED
RELEASED ECO 12 11

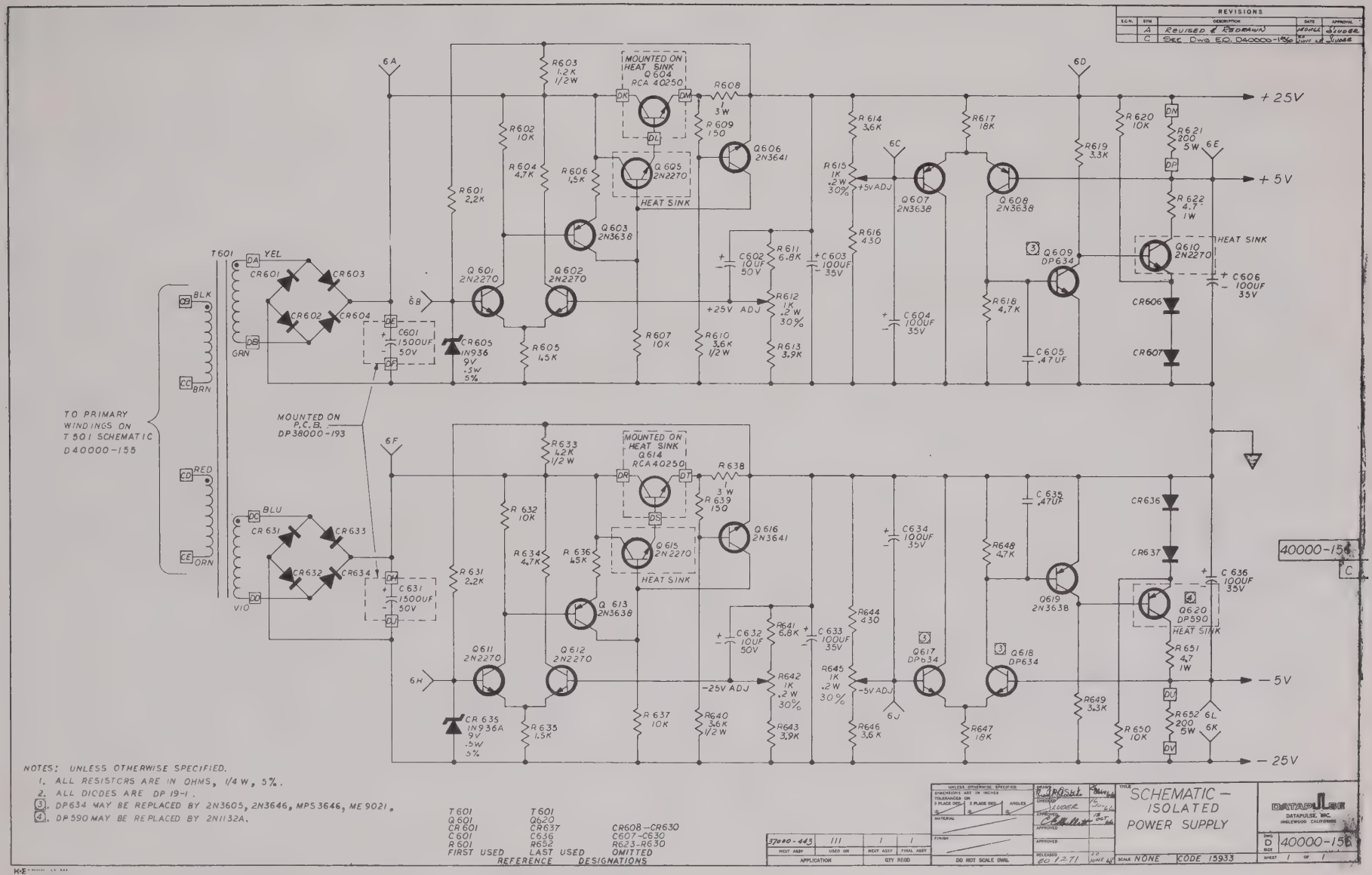
TITLE: SCHEMATIC — GROUNDED POWER SUPPLY

SCALE NONE CODE 15933

DATAPULSE, INC. INGLEWOOD, CALIFORNIA

SIZE D 40000-155

SHEET 1 OF 1



NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTORS ARE IN OHMS, 1/4 W, 5%.
2. ALL DIODES ARE DP 19-1.
3. DP634 MAY BE REPLACED BY 2N3605, 2N3646, MPS3646, ME9021.
4. DP590 MAY BE REPLACED BY 2N1132A.

T601	T601	
Q601	Q620	CR608-CR630
CR601	CR637	C607-C630
C601	C636	R623-R630
R601	R652	
FIRST USED	LAST USED	OMITTED

REFERENCE DESIGNATIONS

37000-445	111	1	1
NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON 3 PLACE DEC. ± .005, 2 PLACE DEC. ± .01, ANGLES ± 1°. MATERIAL. FINISH. DO NOT SCALE DWG.

DRAWN R. PROBST 8 JUNE 66
TRACED
DESIGNED J. SLUDER
ENGINEER C. ALLISON
APPROVED
APPROVED
RELEASED 20 JUNE 66

TITLE: SCHEMATIC — ISOLATED POWER SUPPLY

SCALE NONE | CODE 15933

DATAPULSE, INC. INGLEWOOD CALIFORNIA

DWG D 40000-155 | SIZE D | SHEET 1 OF 1

ADDENDA AND ERRATA

E. O. NO.	EFFECTIVE DATE	DWG. NO.	CHANGE
2500	6-24-68	40000-172	Schematic - Baseline DC Level. 1. Change Q337, Q338, & Q339 from 2N3565 to TZ-82.
2608	10-21-68	40000-170	Schematic - Front End 1. Change C64 from 3.3μF, 35V to 4.7μF, 20V.
2613	10-24-68	40000-155	Schematic - Grounded Power Supply 1. Change R514 & R546 from 3.6k to 12k. 2. Change R516 & R544 from 430 ohms to 2.7k. 3. Change R518 & R548 from 4.7k to 1.2k.
1303	10-29-68	41000-105	Block Diagram 1. "Tunnel Diode Flip-Flop" block should be "Schmitt Trigger Flip-Flop"
2686	3-4-69	40000-156	Schematic - Isolated Power Supply 1. Add R653 (220k) between base & collector of Q615.
2721	5-20-69	Manual	Section 5, Page 5-24, Paragraph 5.10.3 & Page 5-28, Paragraph 5.11.3: Change DP63-4 P/N 22635-004 to DP63-3, P/N 22635-003.
2776	10-15-69	Manual	Page 1-4, Para. 1.16 - Change 0° C to 15° C.
2800	11-6-69	40000-171	Schematic - Output Change R323 from 1.2k, 1/4W, 5%, P/N 10010-122 to 1.5k, 1/4W, 5%, P/N 10010-150.

~~SYSTON DON~~

SYSTRON DONNER

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MR. HAIRER FOR TECH. INFO.

SEMICONDUCTOR REPLACEMENTS

(Applicable to all Datapulse Models except the Model 102).

SERVICE BULLETIN
NO. 1-65
12-24-68

DATAPULSE
SUBSIDIARY OF SYSTRON-DONNER CORP.

The listed commercial equivalent diodes and transistors are suitable replacements for the corresponding Datapulse parts, either as direct substitutes, or as selected for the special performance characteristics given.

DATAPULSE TYPE NO.	DATAPULSE PART NO.	COMMERCIAL EQUIVALENT
Diodes:		
DP15-0	22154-000	1N752A selected for $\Delta V < 0.2V$ between 7mA and 110mA.
DP15-1	22154-001	Same as DP15-0 but matched in pairs to within 0.1V.
DP15-201	22154-201	1N936 selected for 9.4V±0.1V @25mA.
DP16-0	22164-000	1N3600
DP16-1	22164-001	1N3604
DP16-2	22164-002	HPA1003
DP19-0	22194-000	1N2070/1N4005
DP19-1	22194-001	1N4002
DP19-6	22194-006	1N2071/1N4005
Transistors:		
DP43-0	22435-000	2N984
DP46-0	22465-000	2N2964A
DP46-1	22465-001	Selected for h_{fe} = 100 min.
DP59-0	22595-000	2N1132A
DP60-0	22605-000	2N2411
DP60-1	22605-001	2N2894 selected for V_{ceo} (sust) = 20V min.
DP60-2	22605-002	2N2904 or 2N3133
DP60-3	22605-003	2N2894
DP60-4	22605-004	2N3209
DP60-5	22605-005	FT1702
DP60-6	22605-006	2N3640
DP60-7	22605-007	2N2894 selected for V_{ceo} (sust) = 25V.
DP63-0	22635-000	2N2369 or 2N2501
DP63-1	22635-001	2N3723
DP63-2	22635-002	Replaced by DP63-3
DP63-3	22635-003	2N2369A (Fairchild)
DP63-4	22635-004	2N3646 or 2N2369A
DP63-6	22635-006	2N2270
DP63-7	22635-007	2N3261 selected for C_{OB} of 3.3pF or less
DP63-8	22635-008	May be replaced by 2N5109 selected for $h_{fe} \geq 20$ @I_C = 0.25A & V_C = 2.5V
DP63-9	22635-009	May be replaced by 2N5109 selected for $h_{fe} \geq 20$ @I_C = 0.25A & V_C = 2.5V
DP64-0	22645-000	May be replaced by 2N5109 selected for $h_{fe} \geq 20$ @I_C = 0.25A & V_C = 2.5V

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